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CHURCH GABBRO TECHNICAL NOTE: SYSTEMS
DESCRIPTION AND PERFORMANCE

Scott C. Daubin

Rosenstiel School of Marine and Atmospheric
Science

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June 1973

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June 1973

CHURCH GASBRO Technical Note
Systems Description and Performance

by
Scott C. Daubin

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6. ACODAC					
7. MABS					
8. TABS					
9. VLAM					
10. Sonobuoys					
11. Acoustic Sources					
12. SUS Charges					
13. Hydroacoustic Sources					
14. Piezoelectric Sources					
15. Environmental Instruments					
16. XBT					
17. AXBT					
18. SVP					
19. Current Measurements					
20. Wave Profiler					
21. Ships					
22. Laser					
iv					

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by

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This report describes the technical features of systems used in the CHURCH GABBRO exercise during November - December 1972, critiques their performance and recommends future design and operational modifications. Systems discussed include acoustic measurement (ACODAC, MABS, TABS, VLAM and Sonobuoys), acoustic sources (SUS charges Mk61-0 and Mk 82-0, CW Sources HX-231-F and VIBROSEIS), environmental instruments (SBTs, AXBTs, STD, current measurement systems, laser wave profiler) and the ships and aircraft involved.

Forty-six recommendations are set forth for design improvements or operational procedures.

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CHURCH GABBRO Technical Note

Systems Description and Performance

1. Executive Summary

1.1 Purpose

The purpose of this report is to document the systems which were employed in the CHURCH GABBRO exercise, which took place in the Caribbean Sea from 26 November until 15 December 1972, see References (22) and (23). It is intended that this note serve as a technical reference for these systems as well as a means of presenting various problems and deficiencies together with corrective recommendations in order that future exercises may benefit from this experience.

1.2 System Description

Several complex systems were employed and are described technically below. There were the major moored acoustic measurement systems: ACODAC and MABS. There were drifting measurement systems: TABS, VLAM and Sonobuoys. There were acoustic sources: SUS charges Mk 61 and Mk 82, CW sources including the piezoelectric HX 231-F and the hydroacoustic VIBROSEIS. There were environmental instruments: XBT (T-5 and T-7), AXBT, STD, SVP, current measurement arrays including a continuous deep ocean profiling system, laser wave profilers and of course usual shipboard instruments such as echo sounders with precision graphic recorders. Four ships and several aircraft participated. The ship characteristics are outlined and the critical navigation equipment described.

1.3 Conclusion and Recommendations

The overall conclusion is that the systems performed well. In spite of the temporary loss of one mooring and the inability to use its data, ACODACs provided the major part of the data they were intended to record. MABS, TABS, VLAM, and Sonobuoys, all in spite of minor problems, produced useful data from which the scientific objectives can be achieved. The biggest area of disappointment was in the performance of the CW acoustic sources, which were only operative for a small fraction of their scheduled time. However, the signals they projected when "on" were of high quality and produced useful data. SUS charge sequences were successful, more so from ship than aircraft launching. Even in view of the reliability difficulties, the T-5 XBT was a necessary and productive instrument. The four ships involved, USNS SANDS, R/V NORTH SEAL, R/V PIERCE and M/V DEARBORN all performed well; in spite of some aircraft equipment difficulties the air crews conducted their part of the exercise in an excellent manner. Forty-six recommendations, most dealing with design improvements or operational procedures, are set forth.

2. Systems Description and Performance

2.1 Acoustic Measurements Systems

2.1.1 ACODAC

A. General

The ACOustic DATA Capsule (ACODAC) system is a subsurface, moored, self recording acoustic instrumentation system designed to monitor and record acoustic signals and ambient noise at six selected depths throughout the water column. Reference (6) describes the system as it existed in 1971. During the winter and spring of 1972 various changes were incorporated by Texas Instruments Inc. and the Woods Hole Oceanographic Institution under contract to the LRAPP office of the Office of Naval Research and three additional recording and power module (RPM) assemblies were completed. The original two systems after modification are designated "Mod I"; the three new systems assembled by Texas Instruments were designated "Mod II". The performance specifications of the modified systems are presented in Table I.

B. Mooring and Array Designs

Three separate mooring designs were employed in this exercise. Double armored electromechanical cable (U.S. Steel Amergraph 7H37SB and Vector equivalent) was used in the moorings (at Positions H and D); these are termed "hard wire" systems. A multiconductor core surrounded by a polypropylene load bearing braid was used in the mooring at Position B; this is termed a "compliant" system. The two hard wire systems mounted different hydrophones both designed for acceleration insensitivity; hydrophones developed by the Westinghouse Research and Development Center were installed in the mooring at Position H and hydrophones developed by the International Transducer Corporation to University of Miami specifications were installed in the hard wire mooring at Position D and in the compliant mooring at Position B. These different system components were employed both for purposes of field evaluations as well as for inter-comparison of results. Since the three systems were widely separated they did not necessarily experience comparable current regimes; hence inter-comparison for evaluation of straining response was infeasible.

The mooring and array designs with actual depths are shown as follows:

Position	RPM	Mooring Type	Hydrophone	Reference
B	2A4	Compliant	ITC 8020	Figure 1, 2 Appendix A
D	1A1	Hard Wire	ITC 8020	Figure 3
H	2A3	Hard Wire	Westinghouse	Figure 4

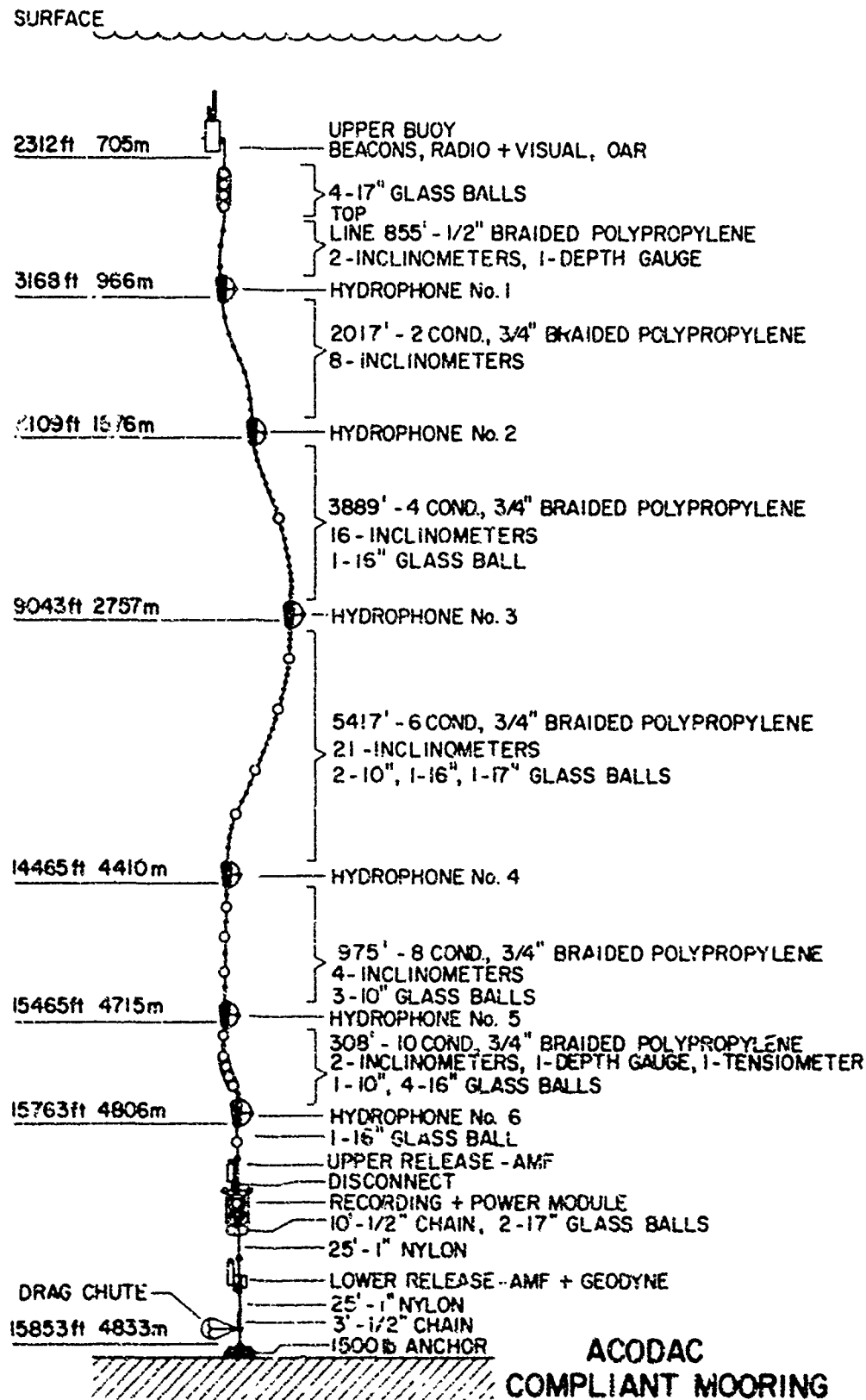
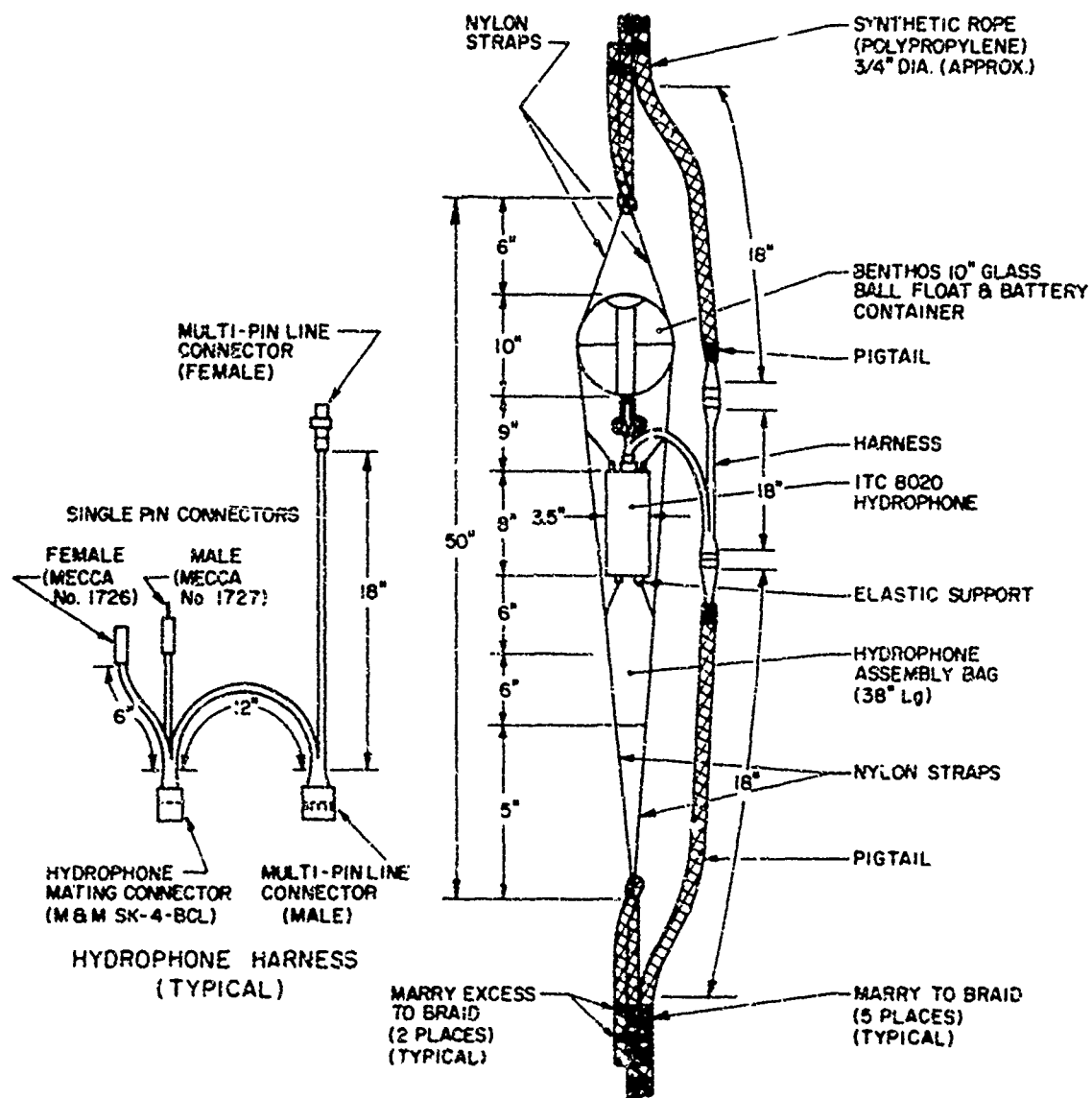
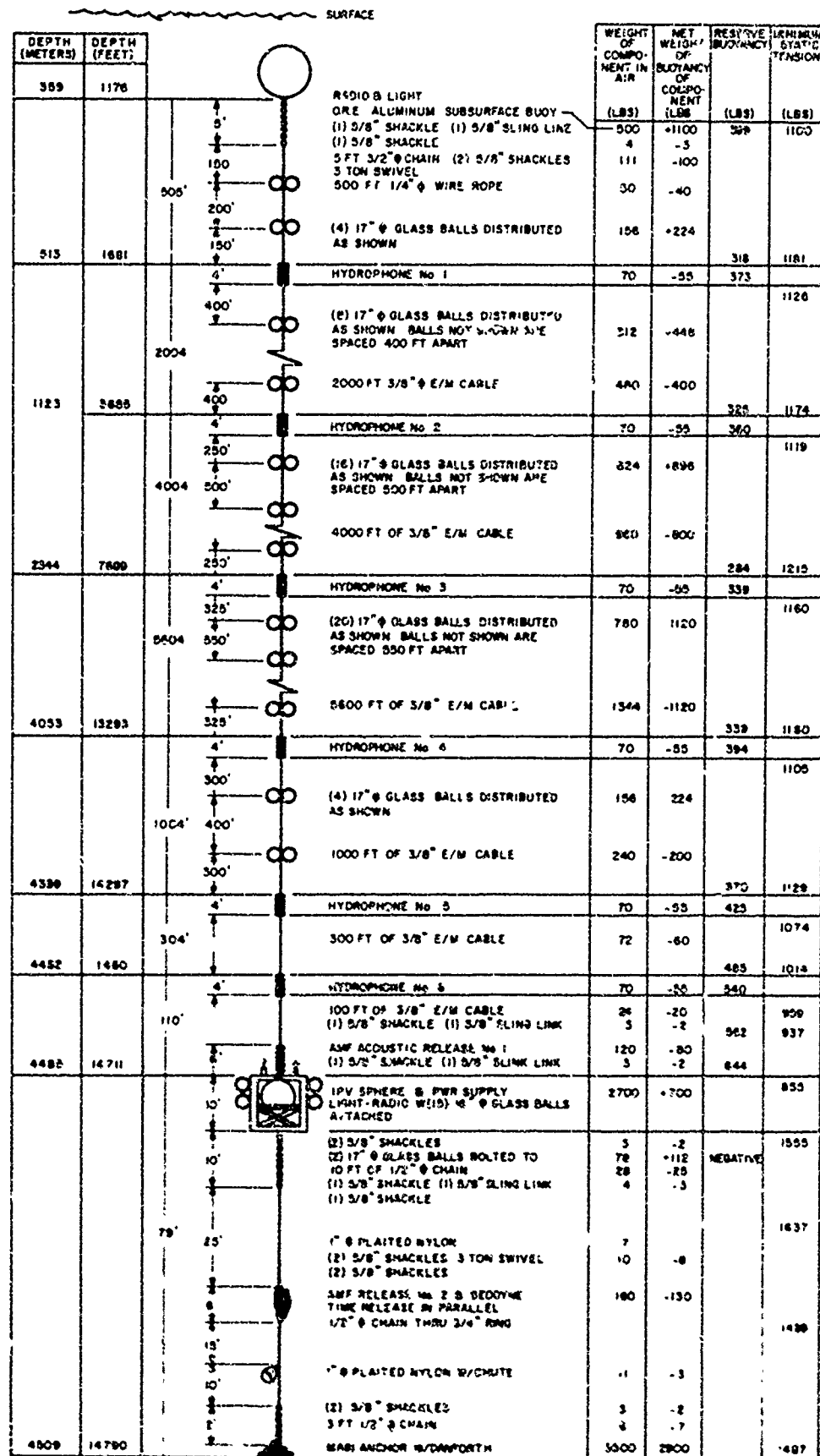


Figure 1



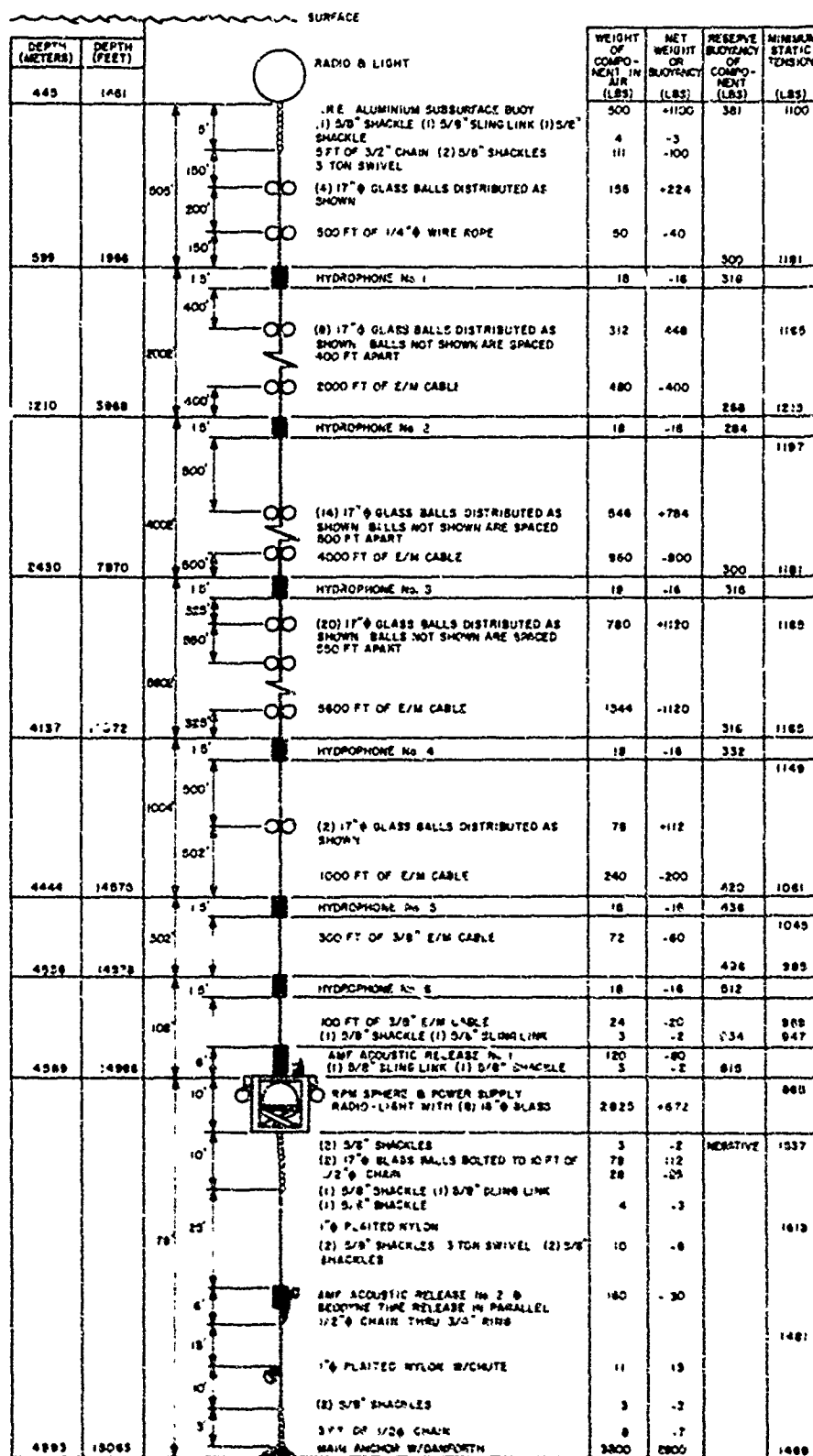
ACODAC COMPLIANT MOORING
HYDROPHONE ASSEMBLY ARR'G'T.

Figure 2



ACODAC MOORING
DEPLOYMENT - 17
POSITION D

Figure 3



ACODAC MOORING
DEPLOYMENT - 18
POSITION H

Figure 4

DATA SYSTEM

Number of Hydrophones	6
Recording Method	Direct Record Analog
Overall Dynamic Range (Per channel)	-70 to 10DB re V/ubar in three automatically selected 27 DB ranges
Tape Speed	15/160 IPS or 15/16 IPS
Overall Frequency Response	15 to 300 Hz or 20 to 3000 Hz within ± 3 DB
Recording Duty Cycle Range	1:1 to 30:1 in selectable integral ratios
Recording Time Per Cycle	1 to 128 minutes selectable
Total Recording Time (Duty cycle = 100%)	10 2/3 days or 25.6 hrs.
Total Bandwidth - Days (BW x # channels x days)	19200 Hertz-days (6 hydrophones)

OPERATIONAL CHARACTERISTICS

Maximum Operating Pressure	9000 psi (Limited by sphere)
Acoustical Telemetry Data	Leak indication Pressure at upper end of hydrophone array Battery voltage
Location Aids	Redundant acoustic transponders
Recovery Method	Redundant acoustic releases
Recovery Aids	Acoustic pinger on capsule Dual radio beacons (27 MHz) Dual xenon flashers

POWER

Main Power Supply	Lead Acid Storage Battery, 17.28 KWH
Auxiliary Supply	Magnesium cells

MECHANICAL

Sphere	38" ID x 1.25" t, 7178-T6 aluminum
Hydrophone E/M Cable	7 Conductor, 3/8" double armored cable Amergraph Type 7437SB

ACODAG Performance Specifications
TABLE I

Table II below lists the pertinent characteristics for the compliant line developed to University of Miami specifications. The central electrical core was manufactured by the Electromechanical Cable Division of the U.S. Steel Corporation, Worcester, Massachusetts; the outer braid was woven by Samson Cordage Works, Shirley, Massachusetts. Figure 5 is a photograph of this cable.

C. Recording and Power Module (RPM)

The assembled RPM is shown in Figure 6. A block diagram of the ACODAC signal processing, recording and telemetry system, most of which is contained within the RPM, is shown in Figure 7. The following discussion concentrates on changes in the system which were effected between the 1971 and 1972 deployments.

(1). Tape Recorder

To prevent tape spillage caused by accelerations, a dual system of dynamic braking of the supply reel and static braking of both the supply and takeup reels was installed. New GeoTech Model 17373 tape recorders were installed in the Mod I systems which had water in the capsules during 1971.

(2). Gain Control

Three basic changes were made in the gain control logic. Previously the system had responded only to average sound pressure level during the one minute integration time and on this level depended the gain state for the following minute; three gain states 10, 37 and 64 db provided three 30 db ranges with 3 db adjacent overlap, for a total system dynamic range of 84 db, matching the hydrophone approximately. The 3 db overlap proved not to be sufficient margin; the ambient level would frequently ride near the margin and the arrival of a transient or fade would overload the system or allow it to sink into noise. Consequently the new systems have four separate gain ranges of 10, 20, 30 and 40 db for a total system dynamic range of 60 db with a 20 db overlap between adjacent bands. The resulting margins allow for a 14 db positive transient in any band without overload as well as a 6 db fade without going into system noise. This band gain scheme together with the resulting acoustic pressure level range of the two hydrophone types are shown in Figure 8. A change in the criteria for gain changes was also made. Previously momentary overloads, although marked as such by simultaneous 75Hz and 200Hz high level signals being injected on the tape, did not automatically cause a downward gain shift during the succeeding minute as long as the average sound pressure level stayed within the bounds. In order to facilitate work with explosives a modification was made which would cause any overload during a given minute to



Compliant Cable

Figure 5

Overall:

Breaking Strength	7,000 lbs
Stretch at Break	30 %
Effective Cable Modulus	31,500 lbs
Buoyancy:	
2 conductors	9.02 lbs/Kft
4 conductors	1.13 lbs/Kft
6 conductors	-6.88 lbs/Kft
8 conductors	-14.85 lbs/Kft
10 conductors	-16.83 lbs/Kft
Type	Free flooding

Electrical Core:

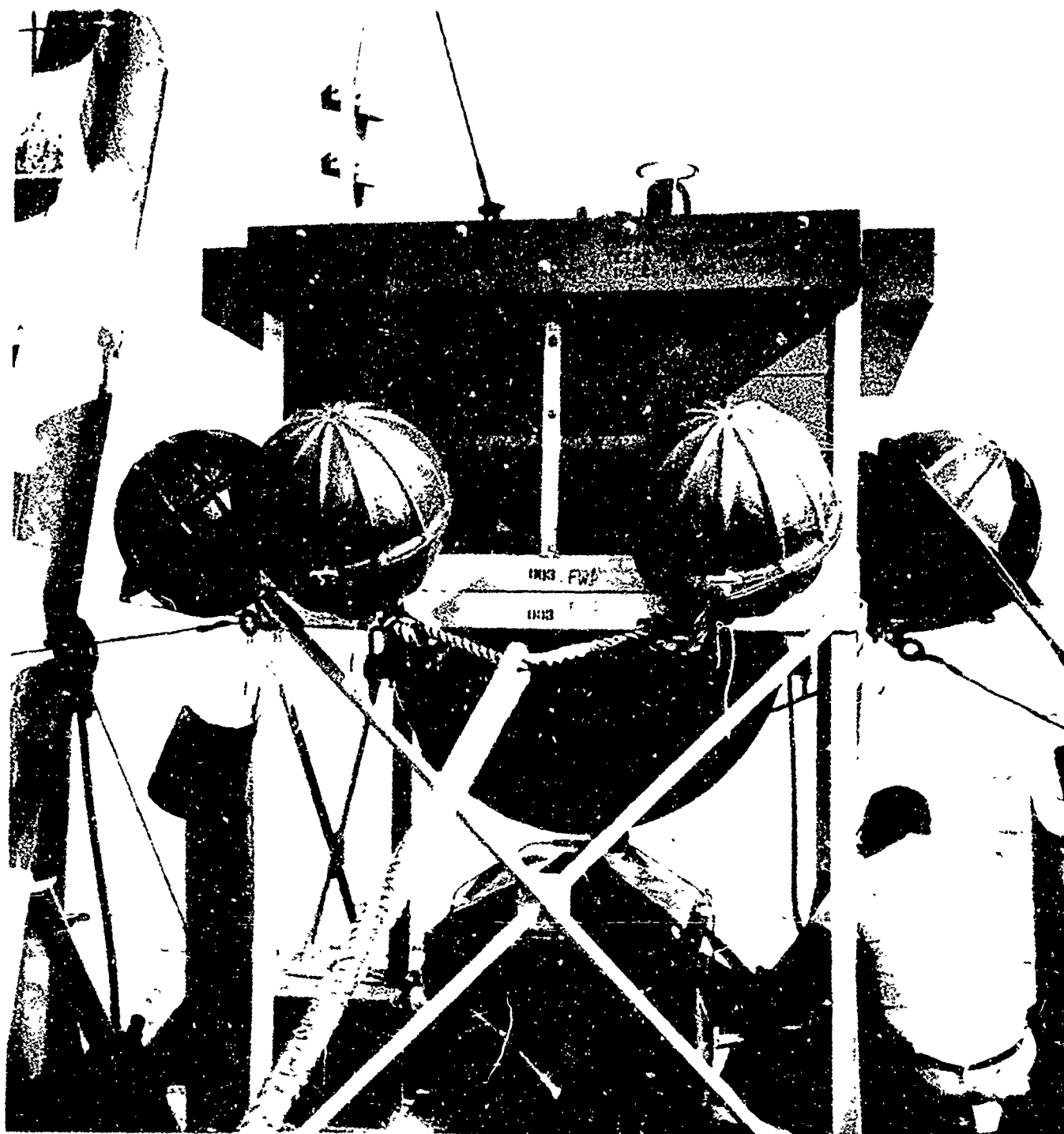
Central Core Diameter	0.300 inch
Central Core Construction	Polyethylene jacket around core of nylon fibers
Wire Arrangement	10 wires or polyethylene fillers wound around core in right hand helix, angle 45°.
Wire Construction	10 AWG #30 wires wound together to form AWG #20 equivalent
Copper Diameter (eff.)	0.032X inch
Insulation Thickness	0.0265 inch
Insulation Material	Polyethylene
Overall Wire Diameter	0.085 inch
Wire Bundle Container	Skeletal braid of nylon

Outer Braid:

Material	Polypropylene
Weight	72 lbs/Kft
Specific Gravity	0.91

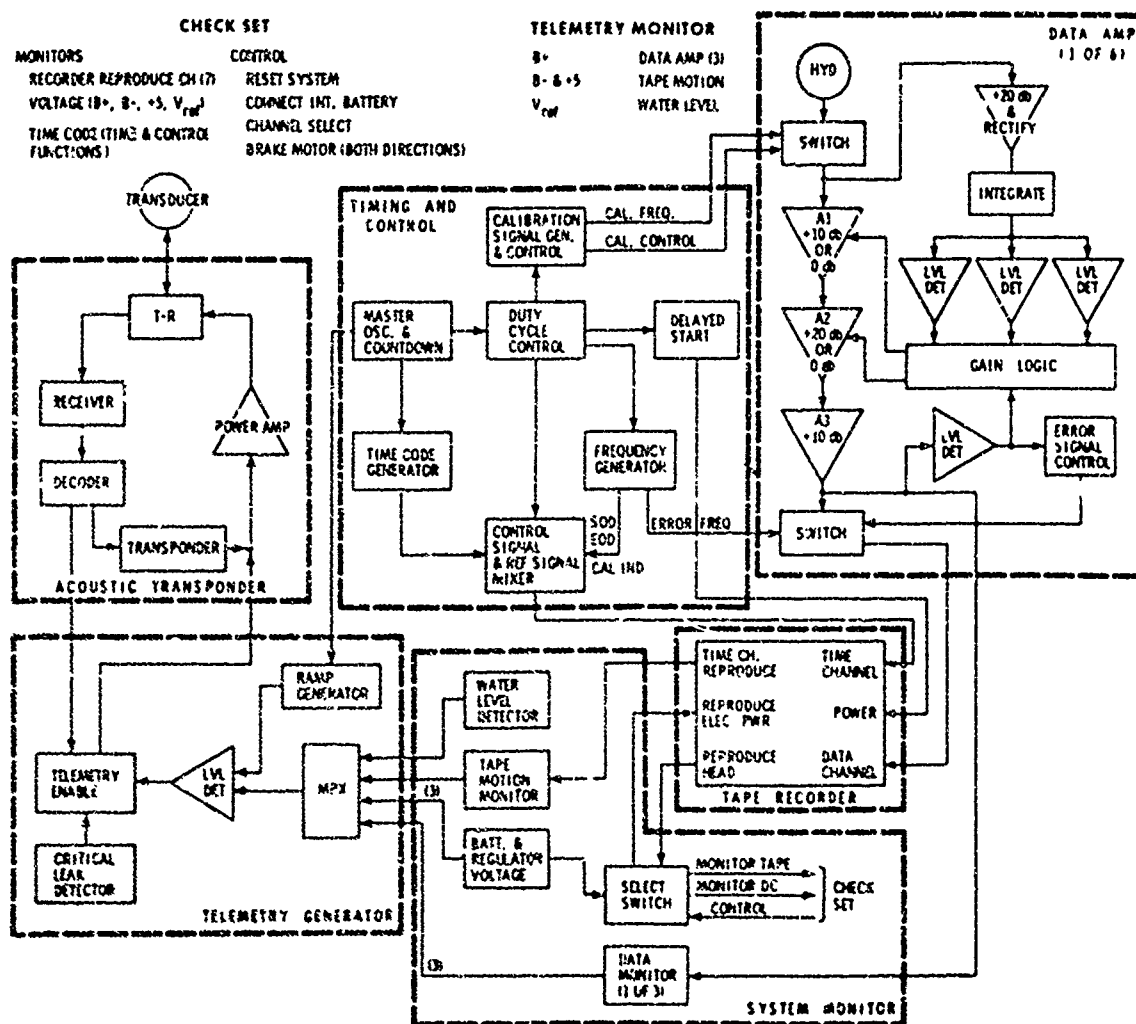
Compliant Cable Characteristics

Table II



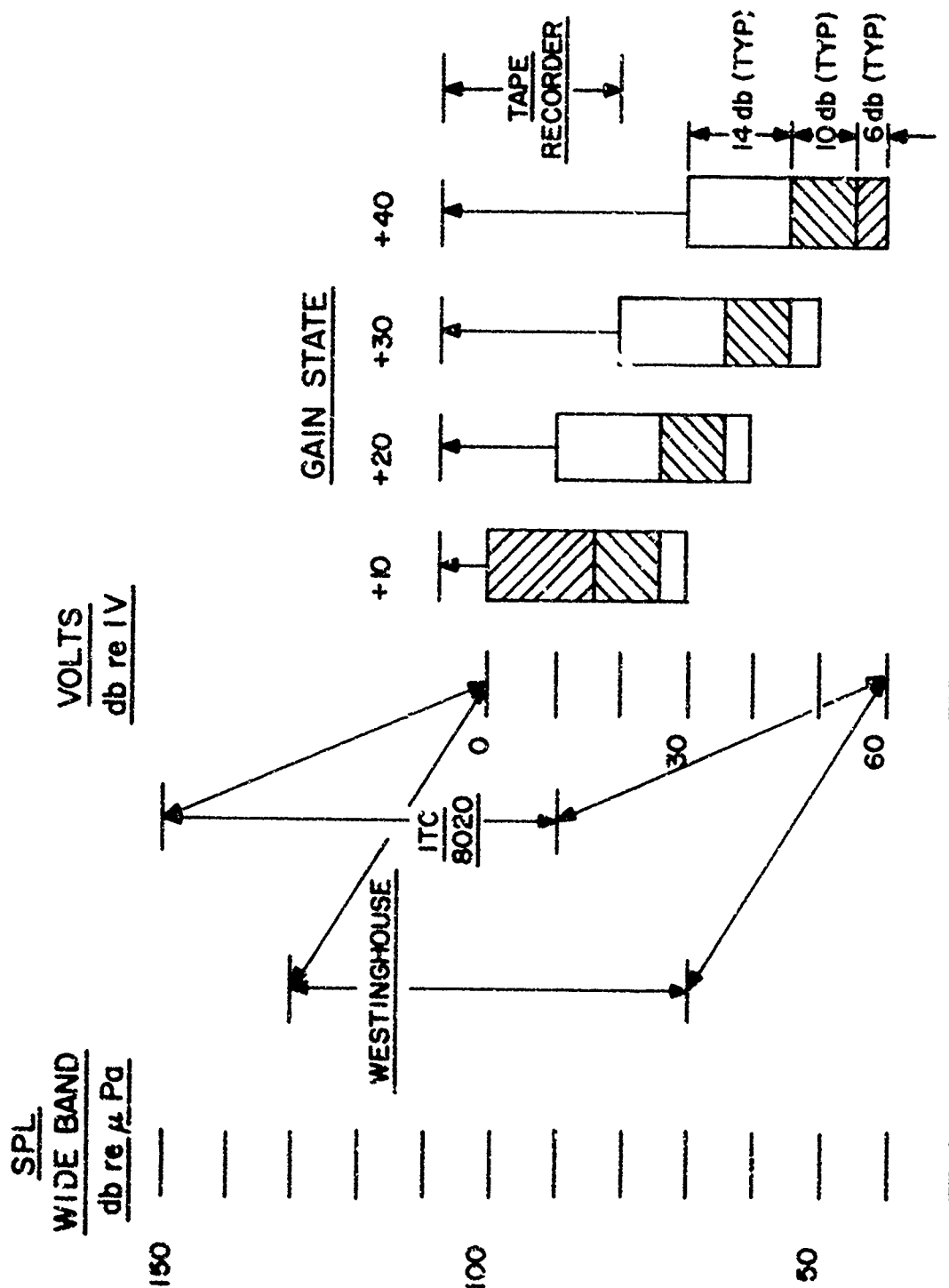
ACODAC Recording and Power Module
November 1972

Figure 6



AODIAC Signal Processing, Recording and Telemetry Systems

Figure 7



ACODAC Level Ranges

Figure 8

cause a downward gain shift during the succeeding minute. The number of minutes the system will remain in the less sensitive state is selectable between 1 and 9 in both the Mod I and Mod II units. In the Mod I unit the system on a momentary overload will at the next opportunity change gain states by one, in the Mod II unit as used in this exercise the system would change by two states if possible, otherwise to the least sensitive state.

(3). Timing and Control

The static brake mentioned above is released by the delayed start signal. All recorded control functions, except overload, have been moved from the data channels to the time code channel.

(4). System Monitor and Telemetry

After the instrument pressure vessel (IPV) has been sealed it is possible with the unit on deck to monitor the signal on each channel, system voltages, gain states, time-code generation and control function generation via an umbilical cable. Control is provided to reset the system clock, connect (or disconnect) the internal battery, select any channel for monitoring and lock (or unlock) the tape reels.

After deployment, the monitor system (via acoustic telemetry) enables the surface ship to query and receive the status of the battery and reference voltages, verify proper signal input to the tape recorder on three preselected channels, measure presence and approximate level of any water in the capsule and extract evidence that the tape had moved during the previous recording period.

(5). Telemetry Generator

The telemetry generator is activated upon receipt of a properly decoded signal from the acoustic transponder. It contains the 8-channel multiplexer and ramp generator that in combination convert the conditional voltage inputs from the system monitor to pulse position modulated time division multiplexed signals transmitted back to the ship through the acoustic transponder.

In addition, if water is detected above a critical level, an alarm circuit is activated that sends a continuing series of pulses through the telemetry system without interrogation.

(6). Acoustic Transponder

The Mod I units utilize the electronics portion of an AMF-262 acoustic release system. The AMF Model 262 is no longer in production, having been superseded by AMF-322, which is in current production. The Model 262 receives amplitude-modulated (suppressed carrier) pulses in an AGC receiver to recover the coded modulation frequency. This was found by AMF to be unreliable when used for underwater navigation purposes (only 70% of replies were received), so the 322 receiver was developed which hard-limits the received pulses, after which narrow-band filters detect the coded modulation frequency. According to AMF, this technique is 100% effective in the navigation utilization. Both receivers utilize the same deck equipment and encoding techniques, so that for ACODAC purposes they can be considered interchangeable at the assembly level. The acoustic transponders in the instrument sphere are utilized only for telemetry purposes. Additional acoustic transponders are provided for release purposes.

D. Hydrophones

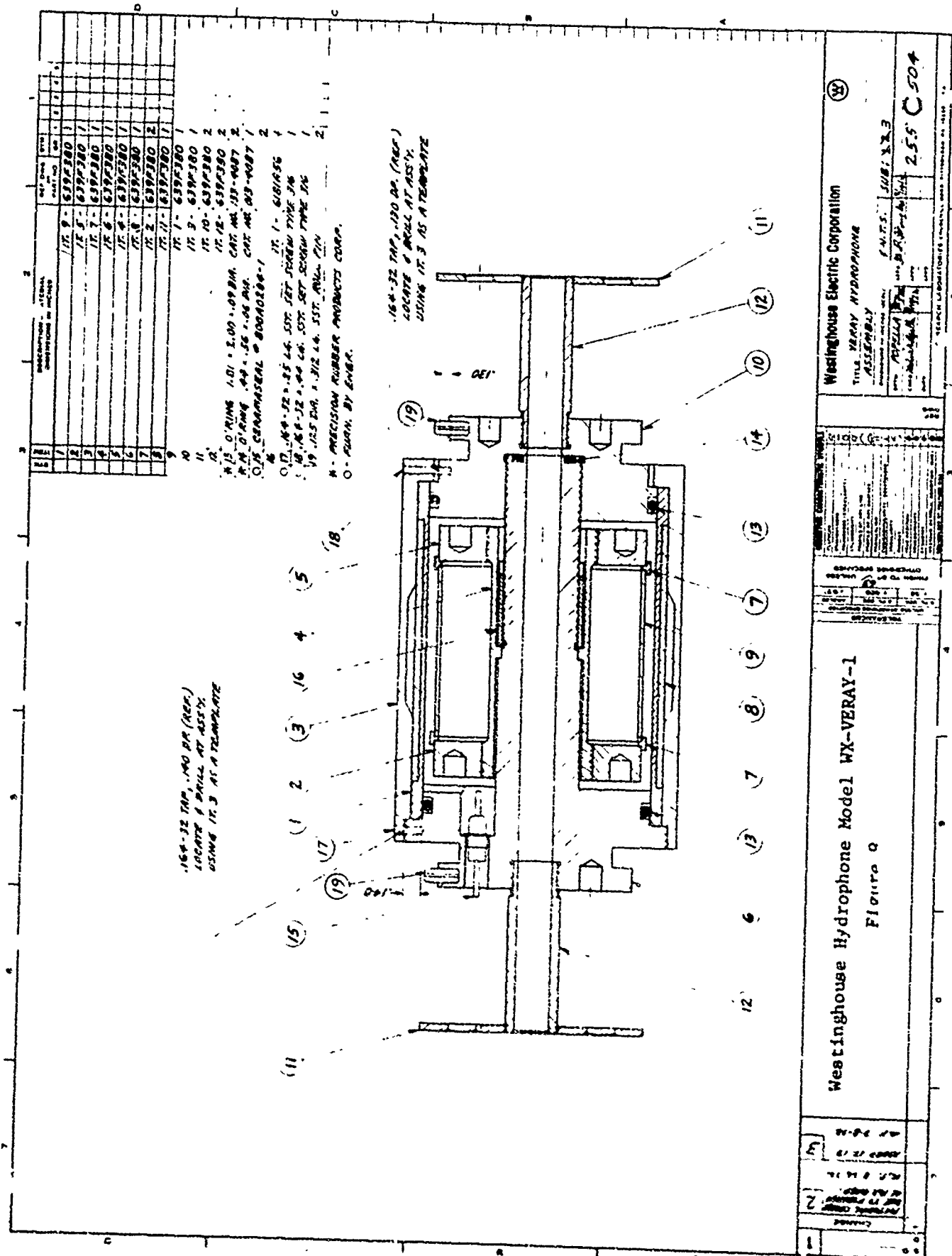
(1). Westinghouse Model WX VERAY-1

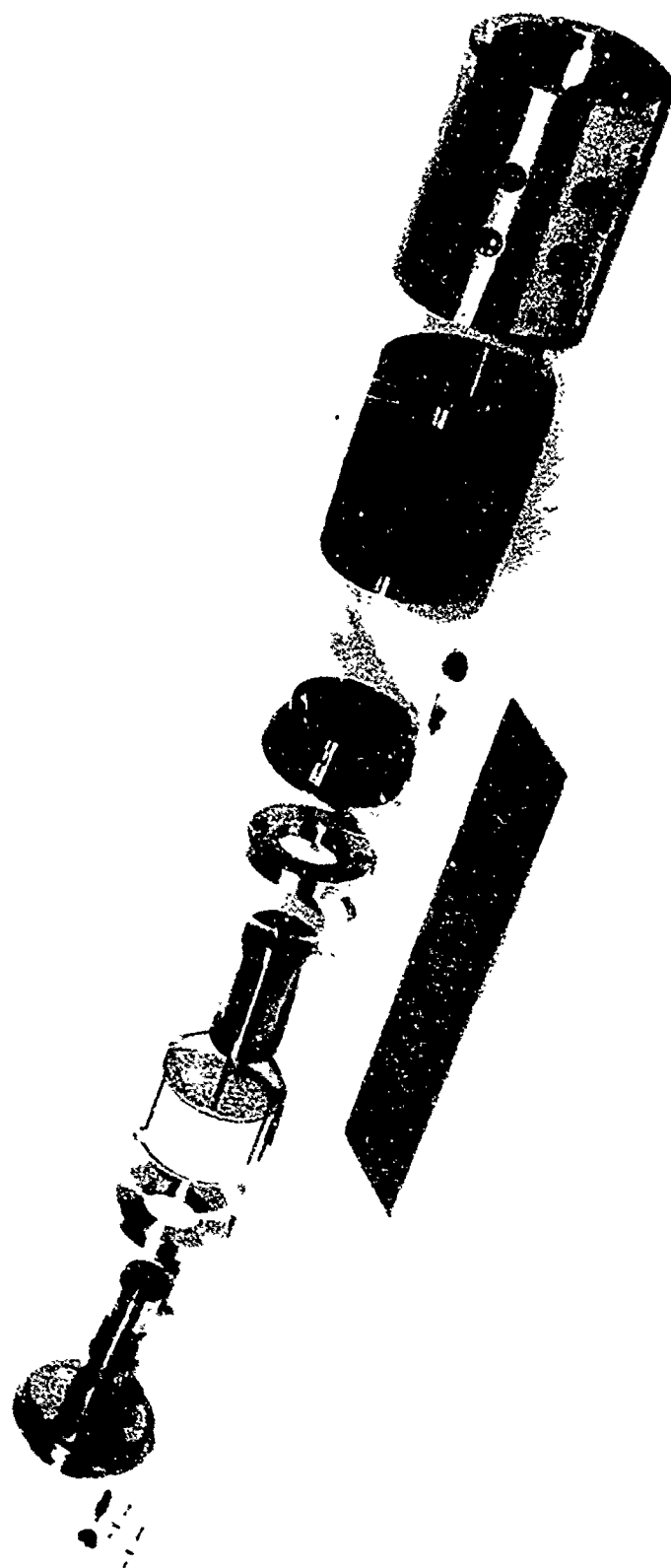
The Westinghouse acceleration cancelling hydrophones used in the exercise were developed at the Westinghouse Research and Development Center, Pittsburgh, Pa. Figure 9 shows the mechanical arrangement of this hydrophone, Figures 10 through 13 show "exploded" to "assembled" photographs of the hydrophone.

With some editing, the following paragraphs are extracted from Reference 31.

Noise Tests of FET Units

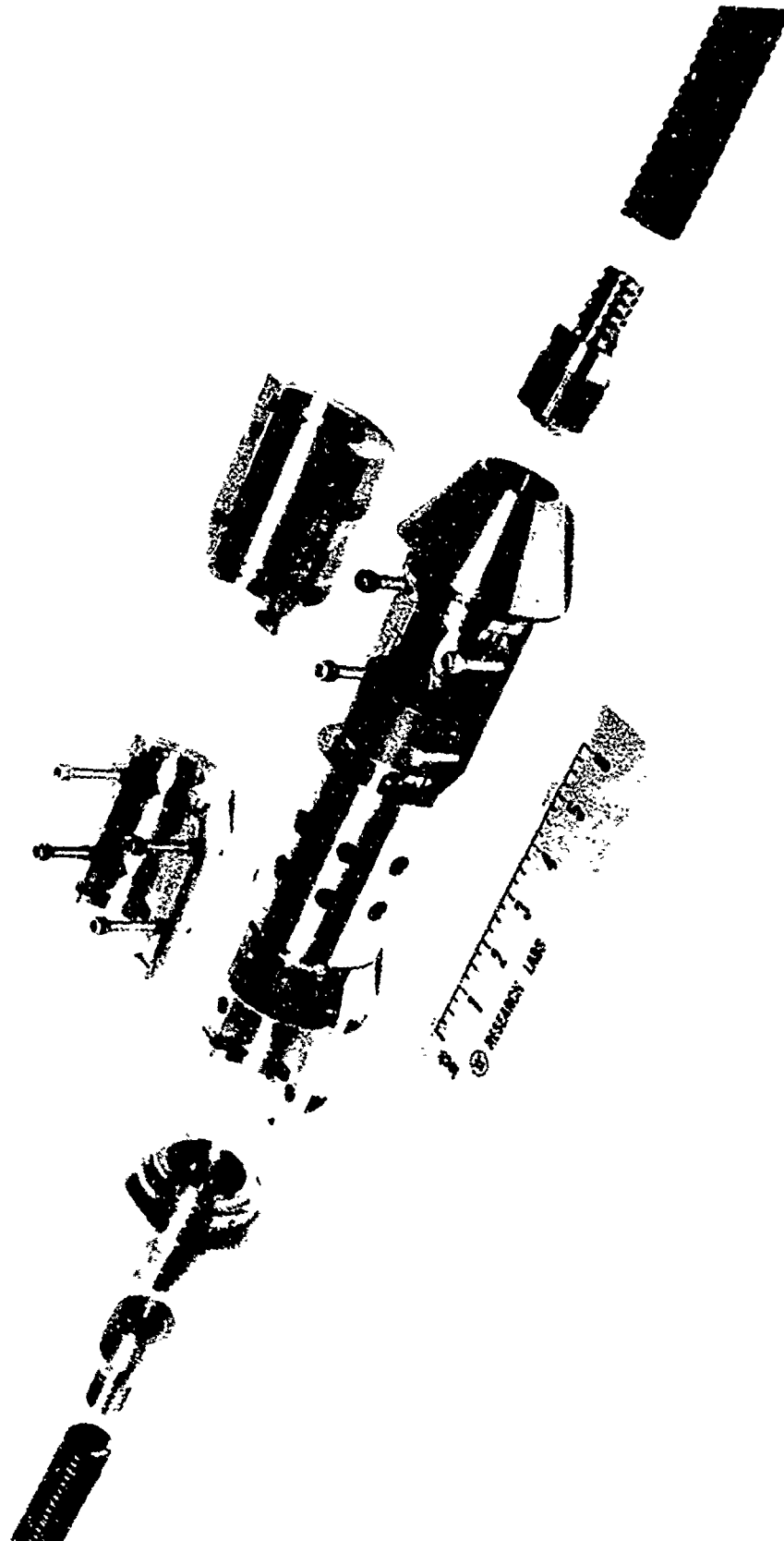
In order to determine whether Crystalonics #C413N silicon epitaxial junction N channel low noise FET units could be used in hydrophone preamplifiers, some units were passivated by the Westinghouse Research and Development Center Solid State Devices Department. The top of the aluminum cans were removed and an organic coating was added. These units were tested in the circuit shown in Figure 14. A 4Hz wide filter was used to examine the FET voltage noise over the spectrum from 10Hz to 300Hz. Figure 15 is a typical plot of the recorded output voltage. The noise at 60Hz and harmonics was large but was ignored. The units were all temperature cycled up to 150°C for 1 hour, returned to room temperature, heated to





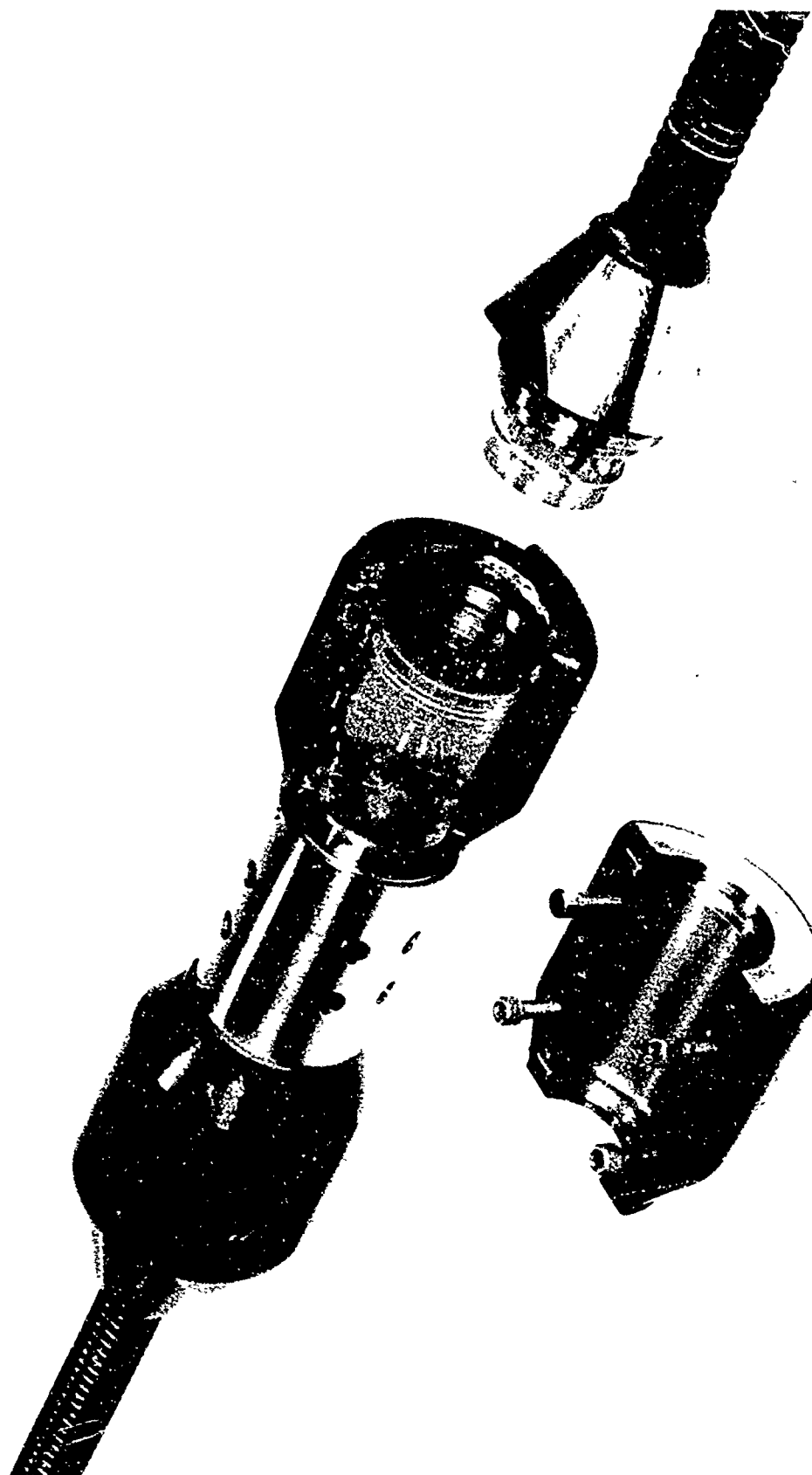
Exploded View
Westinghouse Hydrophone

Figure 10



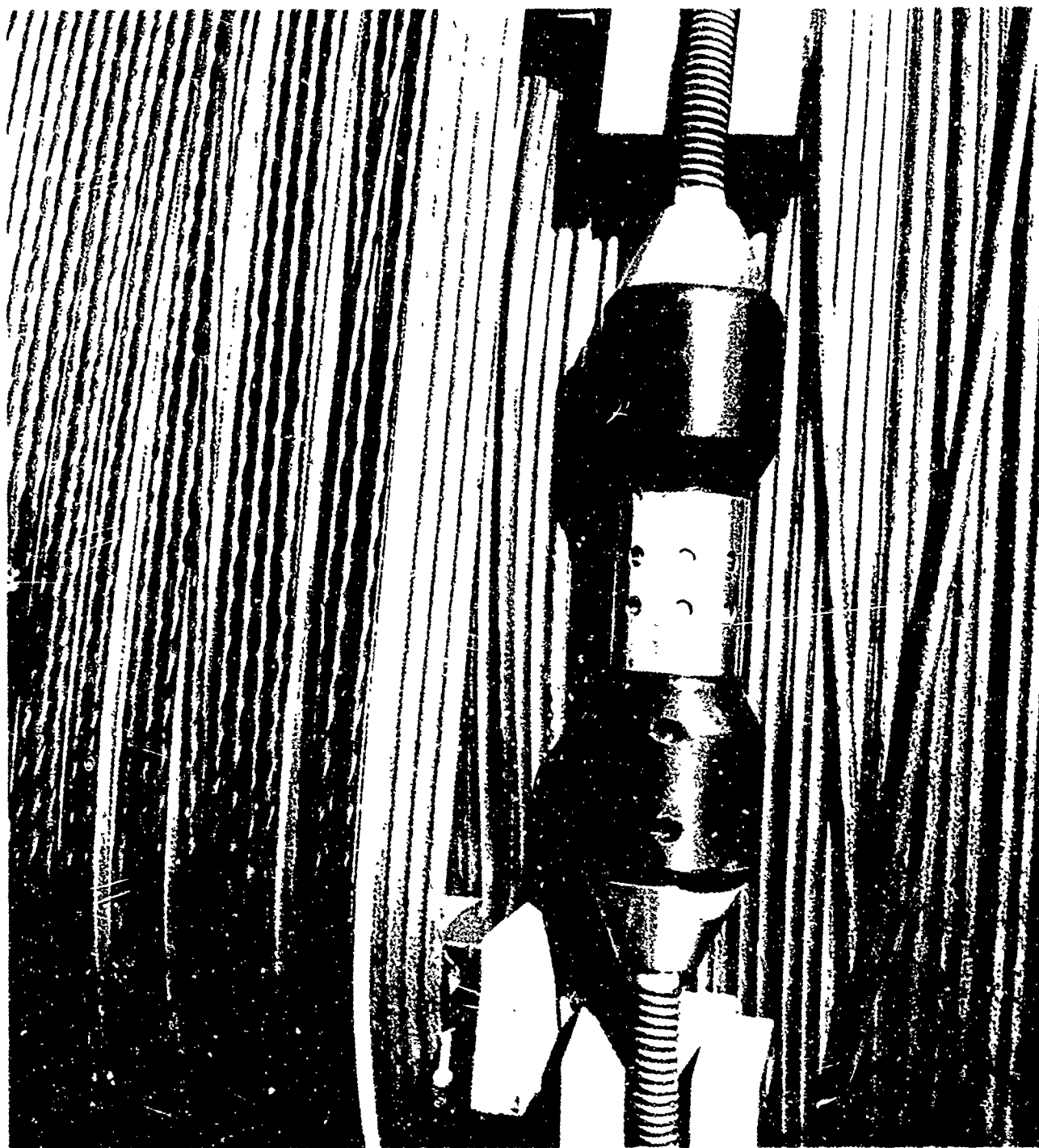
Partially Assembled
Westinghouse Hydrophone

Figure 11



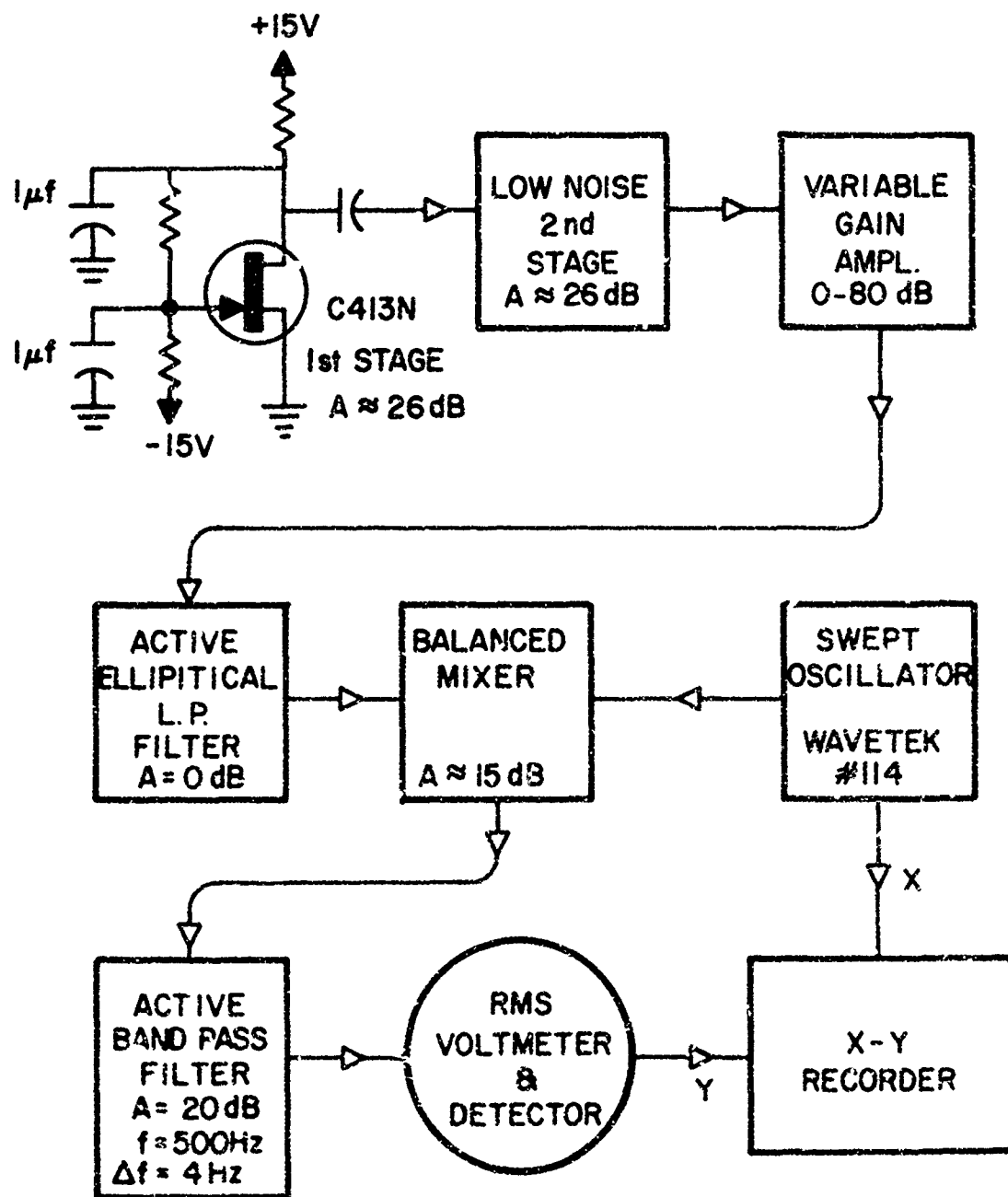
Cable Attachment Scheme
Westinghouse Hydrophone

Figure 12



Assembled Westinghouse
Hydrophone Stowed On Drum

Figure 13



CIRCUIT FOR NOISE MEASUREMENT OF FET UNITS

Figure 14

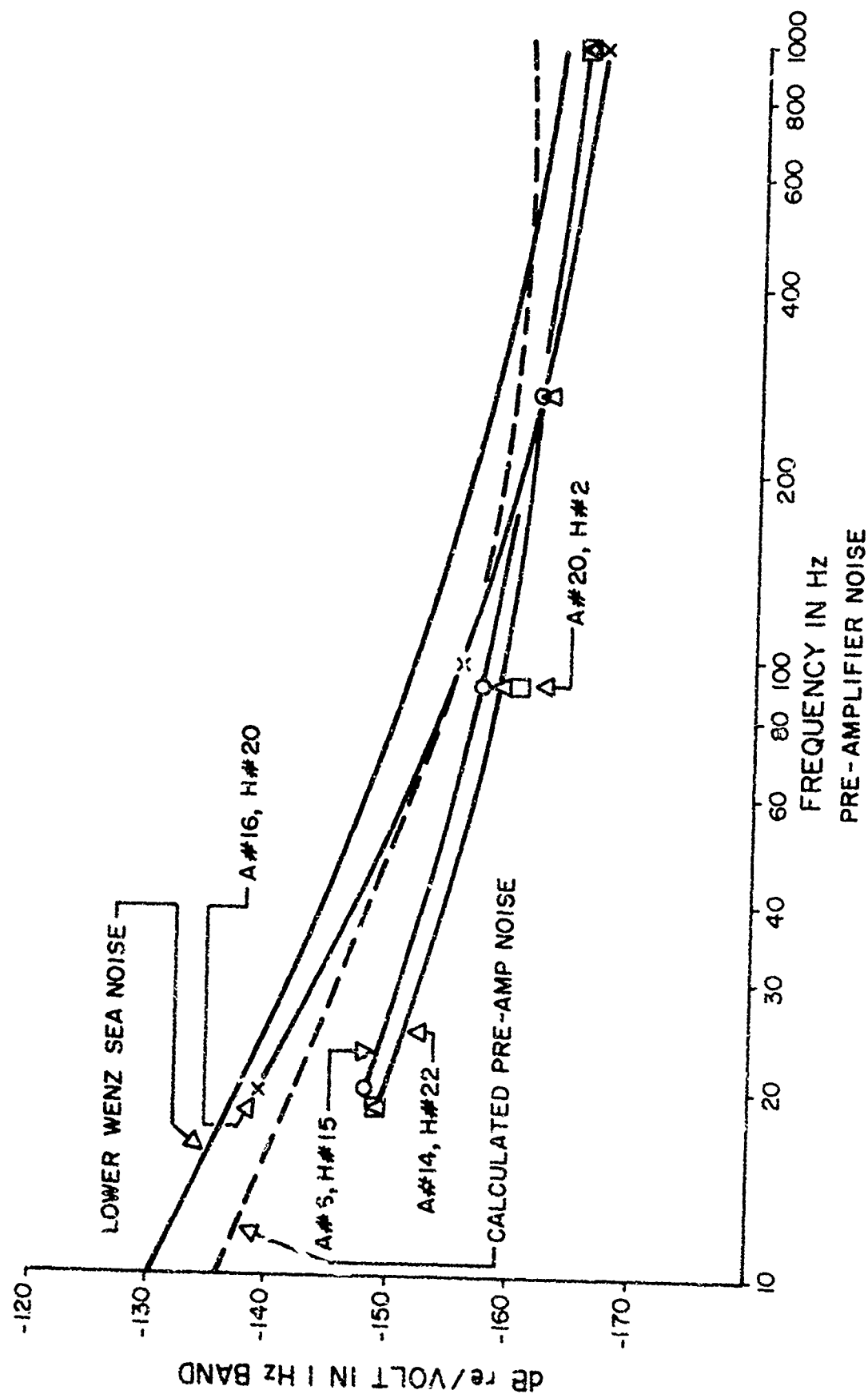


Figure 15

150°C for 2 hours, cooled and tested. Next, the units were placed in a bag of castor oil and were pressure cycled three times to 10,000 psi. Figure 16 illustrates a noise spectrum before and after the tests. Table III summarizes the results at 100 Hz and 200 Hz for the four units. The largest increase was 30% in voltage. This was deemed satisfactory.

Each of the complete preamplifier circuits was tested for noise before assembly to the hydrophone. A dummy RC load was used to simulate the transducer.

Calibration and Pressure Tests

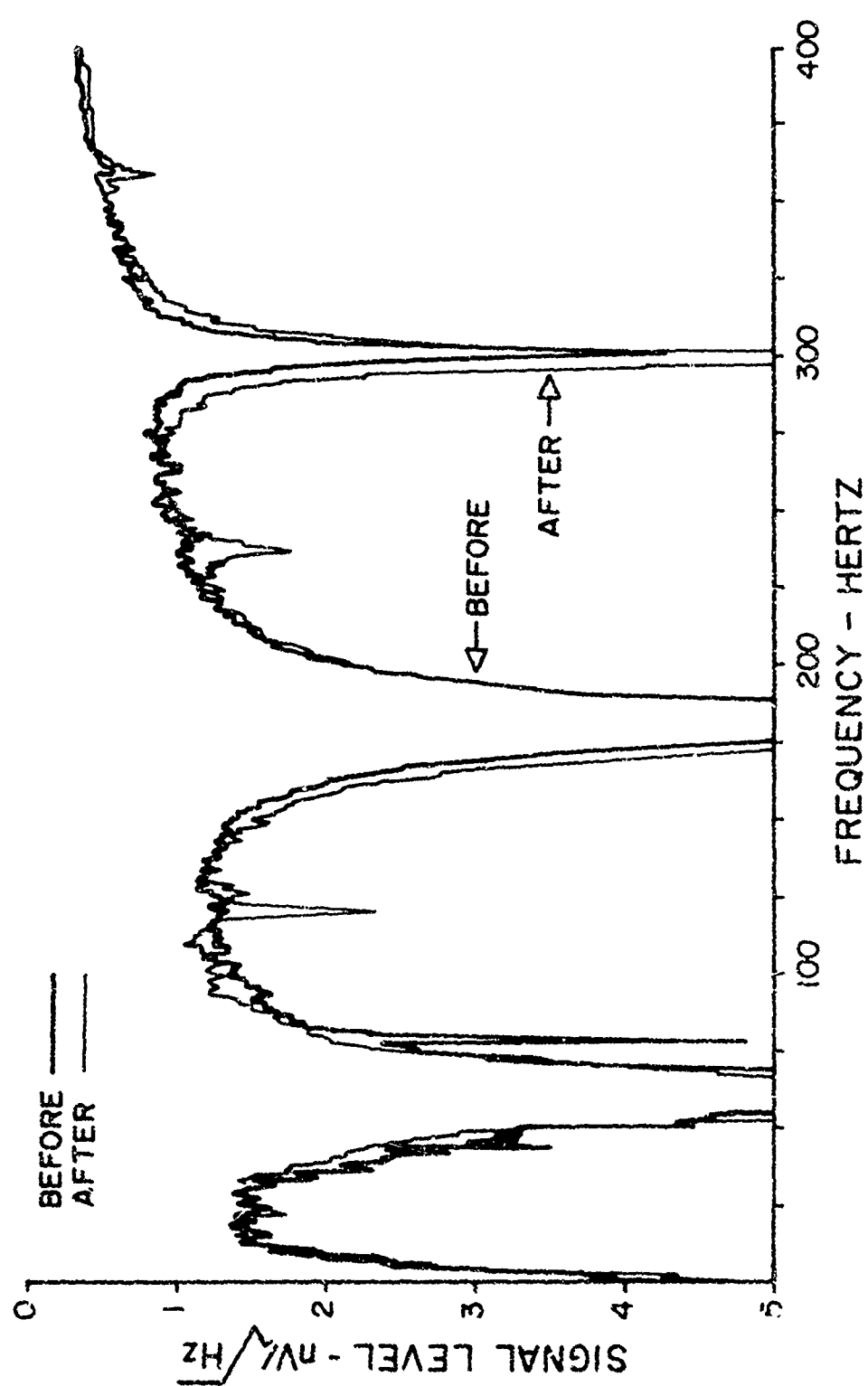
All units were subjected to an 8,000 psi test in a pressure bomb filled with oil. After the pressure test the units were calibrated in air using a 15" speaker driven by an audio oscillator. The strength of the sound field was monitored using a B&K quarter inch condenser microphone Type 4135 with cathode follower Type 2615, having a sensitivity of -71.4 db re v/ μ bar.

Amplifier Tests

The gain of all preamplifier units was measured by inserting a 10 μ v signal at the input terminals and measuring the output voltage from the termination amplifier. A gain between 59 db and 60 db was considered satisfactory. Amplifier noise tests were made at 20, 90, 270 and 1000 Hz using a 1000 ohm resistor in series with a 4700 pf condenser connected to the input terminals, as a dummy source, in place of the hydrophone. After the amplifier units were potted and assembled to the hydrophone, noise tests were made in an anechoic chamber at 270 Hz and 1000 Hz. At lower frequencies the chamber noise masked the pre-amplifier noise. The gain of the number of potted amplifier units was monitored in the pressure bomb as the pressure was slowly varied from 0 to 10,000 psi and back down again. No significant change in gain occurred. The amplifier has 40 db of negative feedback so it has a stable gain even though the characteristics of some of the components change with pressure.

Amplifier Construction

Components were chosen which would stand the pressure. The circuit was designed to avoid the need for any large value capacitors so that monolithic ceramic units could be used. All resistors 1 M Ω and less consist of a metal film on a ceramic rod. The transistor units had to have the covers removed and



NOISE LEVEL OF FET #5 BEFORE AND AFTER TEMPERATURE AND PRESSURE CYCLING

Figure 16

Calculated Input Signal Level in $\text{mV}/\sqrt{\text{Hz}}$ units

Unit No.	Case Type	Before Passivation		After Passivation		After 2 Temperature Cycles		After 3 Pressure Cycles	
		100 Hz	250 Hz	100 Hz	250Hz	100 Hz	250 Hz	100 Hz	250Hz
2	Short	2.8	2.8	2.8	2.5				
3	Short	1.6	1.5	1.8	1.5	1.8	1.5	1.5	1.3
4	Tall	1.2	0.9	1.3	1.0	1.4	1.0	1.3	1.0
5	Tall	1.0	0.8	1.4	0.9	1.3	1.0	1.3	1.0
6	Tall	1.1	0.9	1.3	0.9	1.3	1.1	1.4	1.0
7	Tall	1.2	0.9	1.5	1.0	1.5	1.1	1.5	1.2

Noise Test of Crystallonic #C413N

Table III

be passivated before they were wired into the circuits. This was done after a vacuum bake out. The polyurethane potting material was degassed in a vacuum system before it was poured around the circuit to avoid the formation of gas bubbles. It was cured in an oven under a pressure of 45 lbs. gauge.

Acceleration Tests

To determine the sensitivity of the hydrophone to acceleration the hydrophone was assembled, but prior to oil filling vibration tests were made. Units were mounted so they could be vibrated axially in air using a Goodmans Industries Ltd. Type 390A force driver. The motion was monitored with a consolidated Electrodynamic Corp. Type 4-275 calibrated accelerometer with a sensitivity of -48.6 db re v/g mounted on the hydrophone case. The test was made at 100 Hz and the results are given in Table IV. The response under these conditions was found to be flat from 10 Hz to 300 Hz.

Hydrophone Sensitivity

The overall sensitivity and acceleration response of the hydrophones are shown in Table IV. The Westinghouse hydrophones were designed to measure shipping noise in the ocean. As shown in Figure 8, the ACODAC system is capable of recording signal levels from 1 mV to 1 V over the frequency range from 10 Hz to 300 Hz by using step attenuators of 10, 20, 30, and 40 db. In Reference (30) Wenz shows two solid heavy lines that give the limits of the prevailing noise in the ocean. See Figure 17. Five percent of the time the noise is below the lower curve and five percent of the time it is above the upper curve. A preamplifier that had a noise level at least 1 db below the lower Wenz curve from 10 Hz to 300 Hz was considered satisfactory. The calculated noise levels of the preamp we used was 6 db below the Wenz curve at 10 Hz and 2 db below it at 300 Hz; see Figure 15. This figure also shows the measured response of four of the amplifiers which were measured at 20, 90, 270, and 1000 Hz.

The average noise power represented by the lower Wenz curve from 10 Hz to 300 Hz is the same as the value at 50 Hz. At 50 Hz the curve has a value of

$$+18 \text{ db re } (2 \times 10^{-4} \text{ dynes/cm}^2) = -56 \text{ db re } 1 \mu\text{B}$$

$$= +44 \text{ db re } 1 \mu\text{P}$$

in a 1 Hz bandwidth. Over the 290 Hz band the noise power would increase by a factor of 290 or 25 db. Consequently, the expected ambient noise level is -31 db re 1 μB = +69 db re 1 μP . The overall

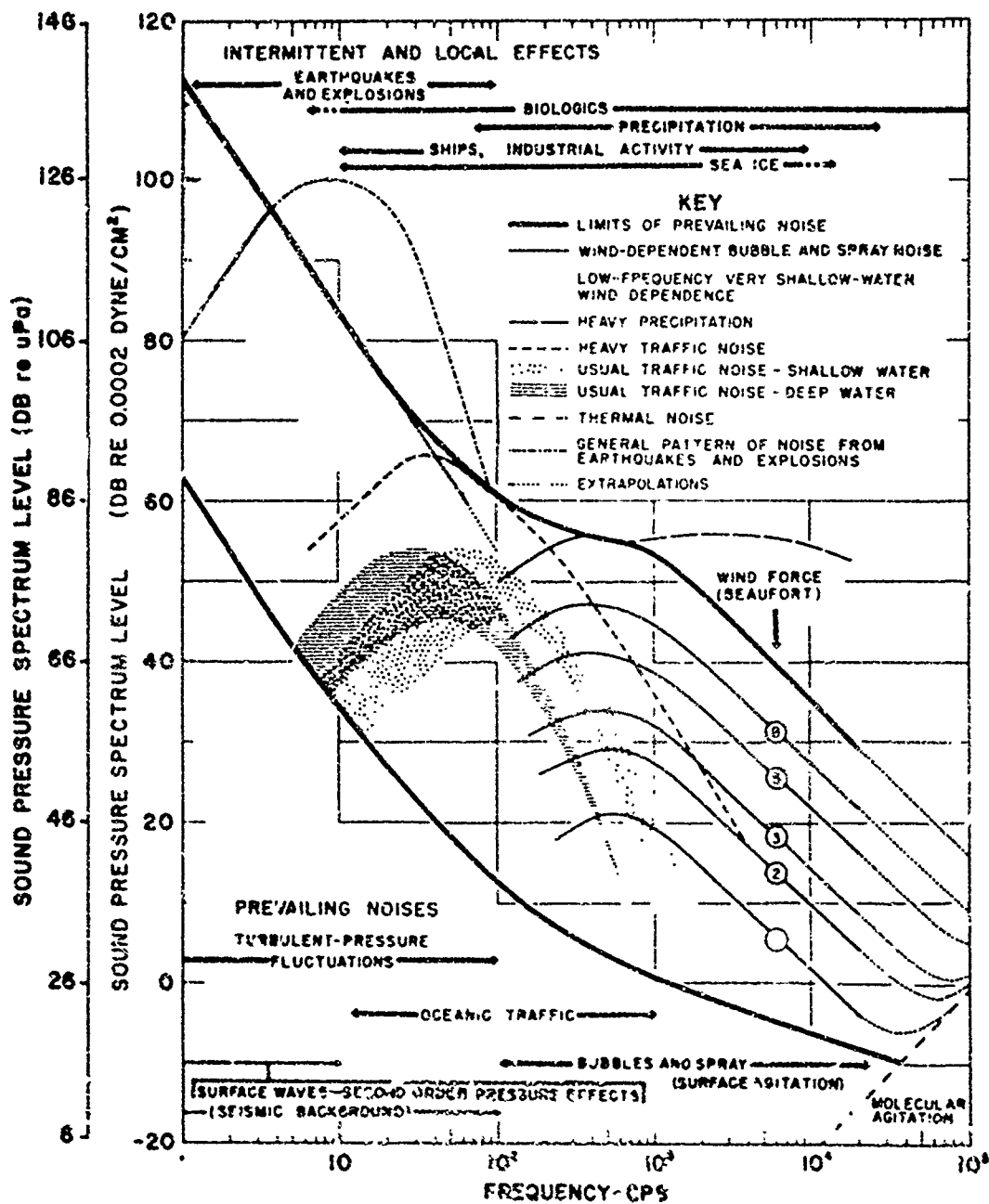
Hydrophone Location	Westinghouse Hydrophone Number	Overall Sensitivity		Acceleration Sensitivity	
		Before Deployment	After Deployment	Before Deployment	
		dBV/ μ B	dBV/ μ B	dBV/mg	
#1 Top	2	-29	-27	-74	
#2	24	-32	-32	-59	
#3	15	-28	-29	-77	
#4	20	-28	-38	-63	
#5	22	-27	-28	-59	
#6 Bottom	27	-27	-28	-58	

Pre Amp Gain = 60 dB

Hydrophone Z = 5,000 pf

Calibration Data for Westinghouse Hydrophones
Used in Deployment 18, November 26, 1972

Table IV



Summary Curves for Acoustic Ambient Noise in the Ocean
(From Wenz (1962), Reference (30))

Figure 17

sensitivity (hydrophone plus amplifier) of the Westinghouse units were about

$$-29 \text{ dbv}/\mu\text{B} = -129 \text{ dbv}/\mu\text{P}.$$

Therefore, a lower Wenz noise level over the band from 10 Hz to 300 Hz would produce a signal level of

$$-60 \text{ db re } 1 \text{ v} = 1 \text{ mv}$$

This is also the lowest level that the ACODAC system will handle; see Figure 8.

When the hydrophones are to be used to monitor explosions or other signals that contain an average power more than 60 db above the lower Wenz curve, then some additional attenuation may be desirable.

Dynamic Range

The Westinghouse system was designed to have a sensitivity of $-29 \text{ dbv}/\mu\text{B}$ and an output range from 1 mv to 1 v (60 db) to match the capabilities of the recording system. The amplifier has a gain of 60 db so the corresponding signal levels at the ceramic terminals are 1 v to 1 mv. The maximum amplifier output is 4 volts before saturating.

Signals from the transducer as large as 1 v will not damage the input transistor. The sensitivity of the piezoelectric element alone is

$$-89 \text{ dbv}/\mu\text{B}$$

so a signal level as great as

$$+89 \text{ db re } 1 \mu\text{B} = +189 \text{ db re } 1 \mu\text{P}$$

will not damage the Westinghouse unit. If larger signals than this are anticipated then a pair of back biased diodes can be used across the input terminals. However, this will reduce the low frequency sensitivity and also will decrease the overall signal to noise ratio of the hydrophone.

Power Converter

The preamplifier requires 30 volts at 14 milliamperes for proper operation. An additional 15 volts is

required to compensate for cable voltage drop and current source simulation. Since the system power supply delivered a nominal ± 12 volts, an up-converter was designed to obtain the required 45 volts. The block diagram for the power converter is shown in Figure 18.

The basic converter consists of a multivibrator free-running at 10 kHz driving a power amplifier whose square wave output is rectified and filtered. Additional circuits provide required auxiliary functions described in the following paragraphs.

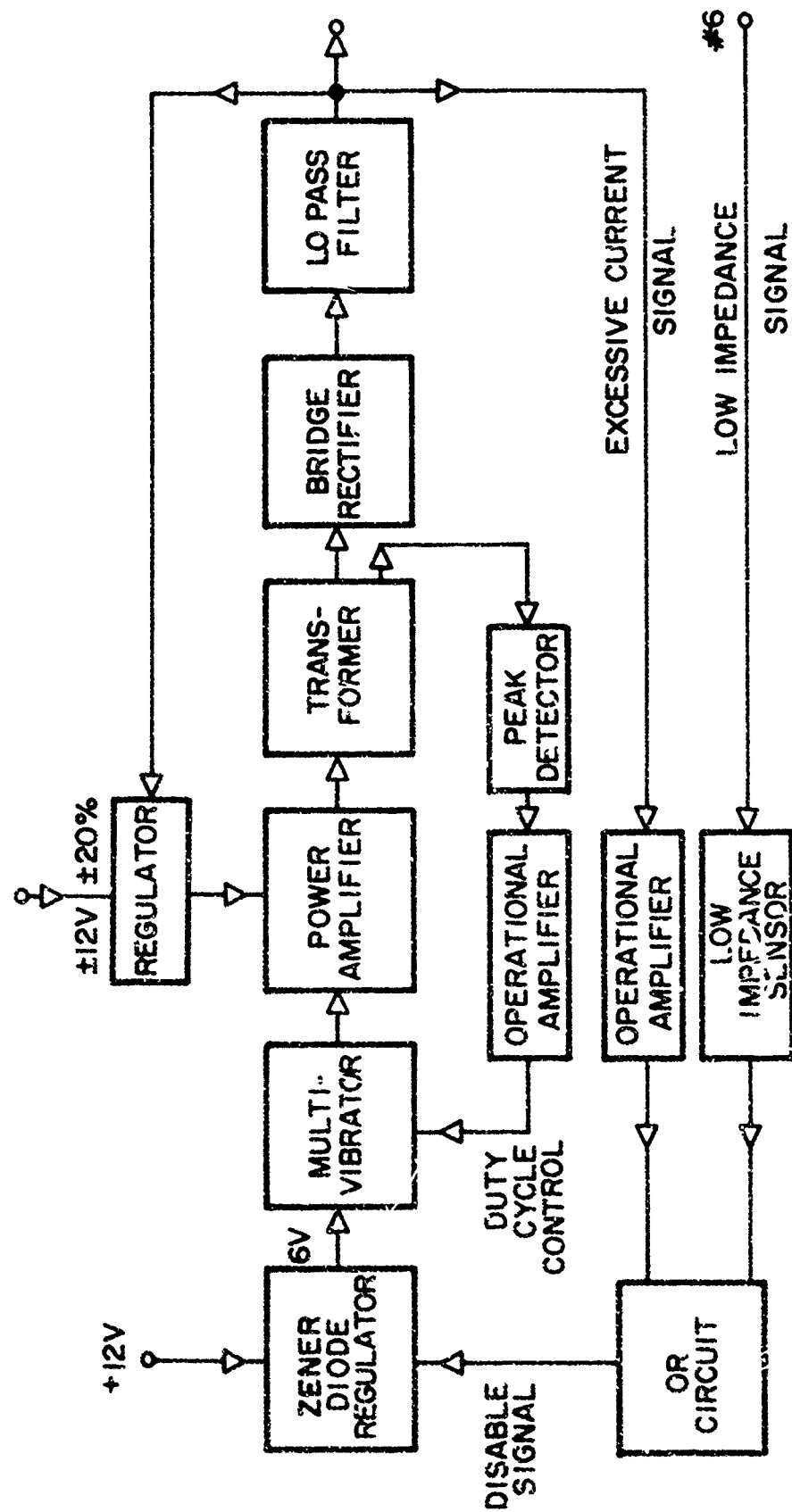
Because the system power is derived from batteries, the supply voltages drop from a high of approximately 14.5 volts to a low of approximately 10 volts as the batteries become discharged. Thus a regulator is required to maintain the amplifier system voltage at 45 volts.

Because of small differences between the positive and negative supply voltages and differing collector saturation voltages of the power amplifier switching transistors, the positive and negative "volt-seconds" applied to the transformer core are unequal. This is equivalent to applying a DC voltage component to the transformer and since the DC resistance is very small, large DC currents can flow which saturate the core. A duty cycle control circuit is included in the converter which senses unequal positive and negative "volt-seconds" in the core and adjusts the multivibrator duty cycle so as to make them equal.

The converter is protected against excessive output current due to accidental shorts or other high load situations. If excessive current is sensed, a circuit shuts off power to the multivibrator thus removing the power amplifier drive signal and yielding zero output. Once this circuit has been activated, it must be reset by first removing and then reapplying the system power.

In ACODAC deployment number 18 the input to the impedance sensor came from the lead connected to the bottom hydrophone. In the future it would be more desirable to use the unused pin #7 on the XSL8CCP connector with the connector attached the resistance from pin #7 to ground would be very high but if the connector were to part, the salt water would reduce the impedance to 500 ohms or less.

The presence of either a low impedance signal or an excessive current signal will cause a signal from the "or circuit" to disable the diode regulator.



WESTINGHOUSE UP CONVERTER, VOLTAGE REGULATOR, AND PROTECTIVE CIRCUITS

Figure 18

(2). ITC Model 8020

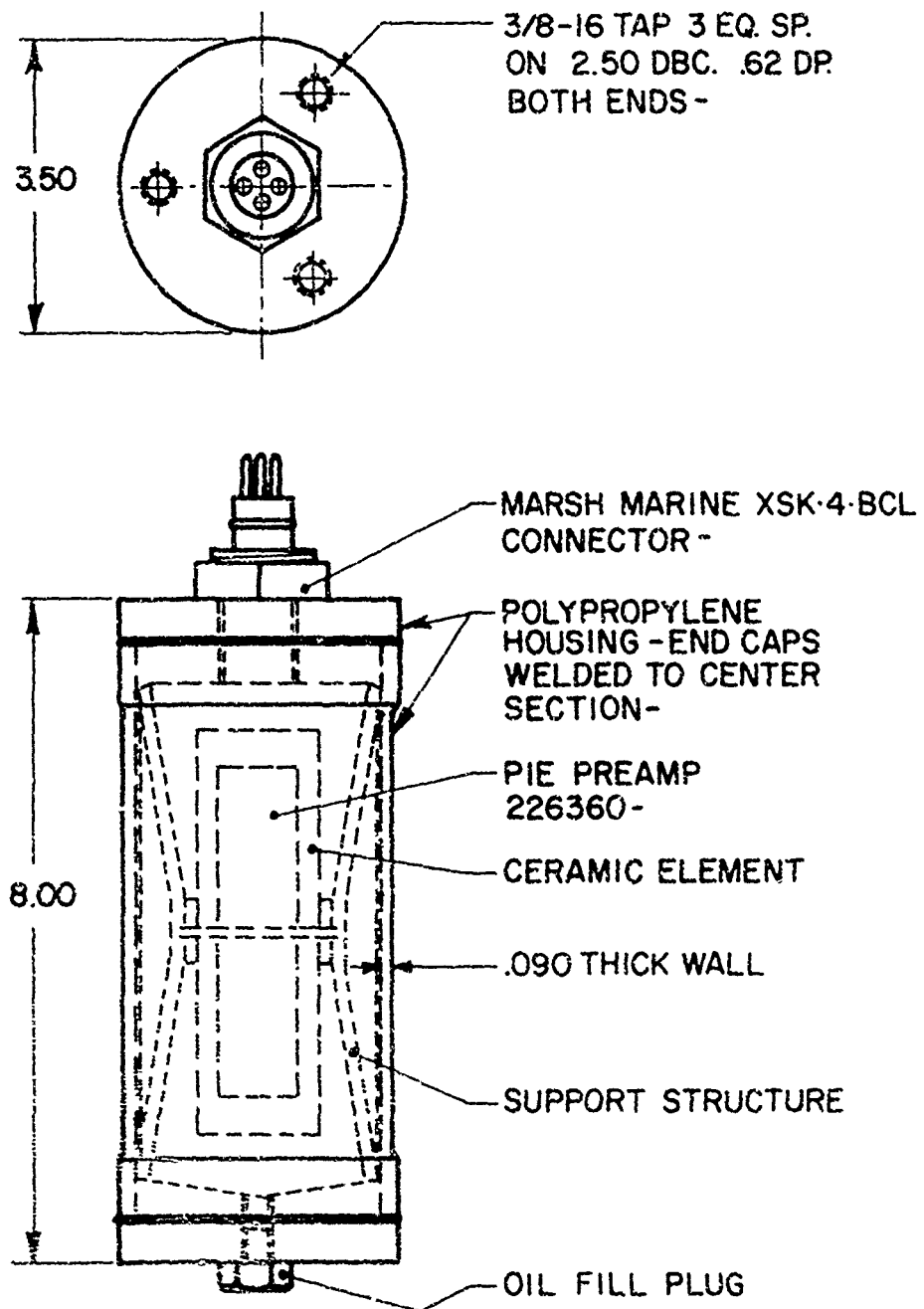
A discussion of the rationale behind the development of the ITC Model 8020 hydrophone is given by Reference (7). These units were developed by the International Transducer Corporation, Santa Barbara, California. The ITC 8020, Figure 19, was designed to overcome some of the shortcomings of the ITC 8004. First it was made as completely symmetric as possible by moving the preamp to a location inside the sensitive element. In order to accomplish this, the pressure vessel was eliminated and the electronics were designed for operation at full hydrostatic pressure. Figure 20 is a schematic of the pre-amplifier. An important consequence of the elimination of the pressure vessel is weight reduction; the ITC 8020 weighs only about 0.9 lb in sea water. This permits support by very soft elastic members (surgical tubing) which results in a very low natural frequency of the suspension and high attenuation of vibration. Second, the hydrophone walls were made much more rigid than previously.

The ITC 8020 was developed in response to University of Miami specifications; Appendix C. These were subsequently modified to require a - 150 db re v/uPa response instead of - 140. Fourteen units were produced. All units, except one, which was held as a spare, were tested at the Underwater Sound Reference Division of the Naval Research Laboratory, Orlando, Florida from 30 October through 3 November 1972. The results of this test showed a response of approximately - 150 db re v/uPa which was insensitive to temperature and pressure changes within the specified frequency range. Appendix B presents the essential data from the test report, Reference (29).

The circuit and data for the hydrophone power supply are shown in Figure 21.

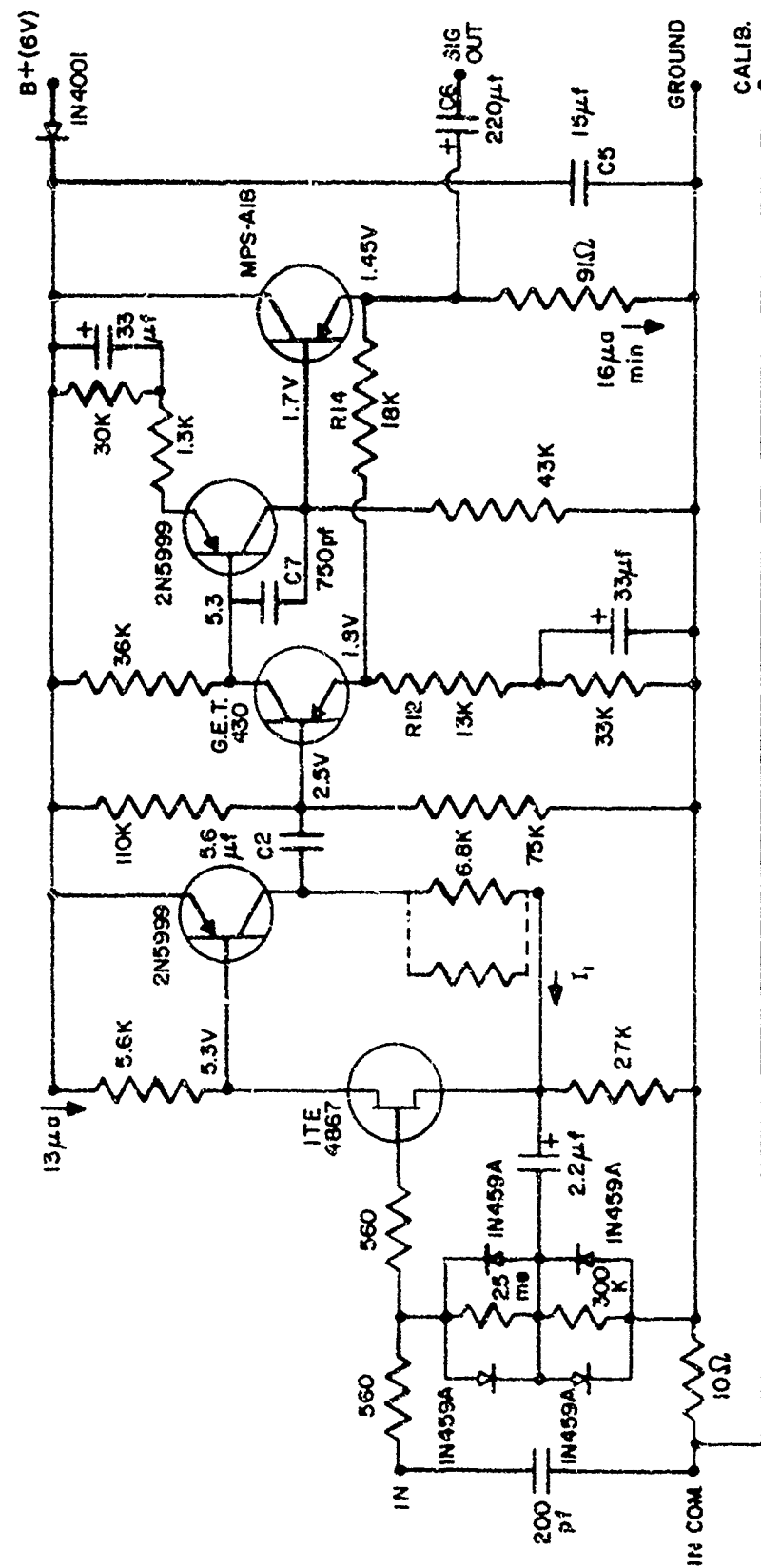
E. Deployment and Recovery

Deployment and Recovery Logs are presented in Figures 22, 23, and 24. Track charts for the deployments of the three systems are shown in Figures 25, 26, and 27. All systems were placed in water deeper than the nominal 4390 meters because sound velocities derived from XBT's dropped from NORTH SEAL indicated a deeper sound channel than anticipated. Data from Figure 4-45 of Reference (16) indicated a critical depth in the summer of 4750 meters and in the winter of 4250 meters. In planning the exercise a critical depth close to the winter value was assumed; this was an erroneous assumption. As shown in Figure 28 the actual critical depth was between 4450 and 4500 meters. The objective was to place hydrophone number 5 at the critical depth. The depths of hydrophone



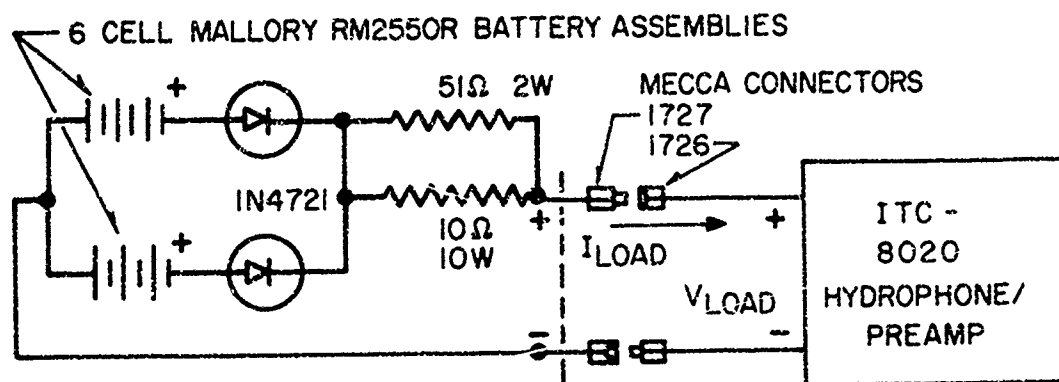
Hydrophone Model ITC 8020 Outline Drawing

Figure 19



Preamplifier for Hydrophone
Model ITC 8020

Figure 20



	<u>"NEW" AT 22°C</u>	<u>"END-OF-LIFE" AT 0°C</u>
CELL VOLTAGE	1.36 V	1.20 V
BATTERY VOLTAGE	8.18 V	7.20 V
V _{DIODE}	0.60 V	0.60 V
I _{LOAD}	21 ma	17 ma
I _R	0.18 V	0.14 V
V _{LOAD}	7.40V	6.46 V

ESTIMATED LIFE (TO 1.20 V/CELL): $320 \text{ hrs} \times \frac{30}{20} = \underline{480 \text{ hrs}}$

WITH CATASTROPIC FAILURE
OF ONE BATTERY

$$I_{\text{SHORT-CIRCUIT}} \approx \frac{7.5\text{V}}{10\Omega} = 750\text{ma}$$

ITC 8020 HYDROPHONE
PRE-AMP POWER SUPPLY

Figure 21

ACODAC DEPLOYMENT AND RECOVERY LOG

Experiment CHURCH GAUBRO Area NW CARIBBEANACODAC System No. Mooring Type Woods Hole Freq. Band 15 300 HzHydrophone Type ITC 8020 Weather ClearSea Conditions Swell of 4' from SE

Deployment:

Deployment Method RPM last DEPL. NO. 17

	Lat.	Long.	Date/Time (GMT)	Course (°T)	Speed (kts.)
Commenced Operations	<u>17</u> - <u>21.0</u> N	<u>85</u> - <u>44.2</u> W	<u>28</u> / <u>1100Z</u>	<u>295°</u>	<u>0</u>
1st Gear in Water	<u>17</u> - <u>22.3</u> N	<u>85</u> - <u>45.8</u> W	<u>28</u> / <u>1204Z</u>	<u>295°</u>	<u>2.1K</u>
IPV in Water	<u>17</u> - <u>34.4</u> N	<u>86</u> - <u>01.3</u> W	<u>28</u> / <u>2013Z</u>		Water Depth (M)
Anchor Dropped	<u>17</u> - <u>34.4</u> N	<u>86</u> - <u>01.3</u> W	<u>28</u> / <u>2014Z</u>		
Mooring Position	<u>17</u> - <u>34.3</u> N	<u>86</u> - <u>00.5</u> W	<u>28</u> / <u>2110Z</u>		

Recovery

	Lat.	Long.	Date/Time (GMT)	Course (°T)	Speed (kts.)
Commenced Operations	<u>17</u> - <u>33.4</u> N	<u>86</u> - <u>02.3</u> W	<u>09</u> / <u>0830Z</u>		
Mooring Release	<u>17</u> - <u>33.0</u> N	<u>86</u> - <u>04.3</u> W	<u>09</u> / <u>1000Z</u>		
Mooring on Surface	<u>17</u> - <u>33.0</u> N	<u>86</u> - <u>04.3</u> W	<u>09</u> / <u>1005Z</u>		
Mooring on Board	<u>17</u> - <u>33.8</u> N	<u>86</u> - <u>02.1</u> W	<u>09</u> / <u>1308Z</u>		
IPV Release	<u>17</u> - <u>33.6</u> N	<u>86</u> - <u>02.5</u> W	<u>09</u> / <u>1100Z</u>		
IPV on Surface	<u>17</u> - <u>33.6</u> N	<u>86</u> - <u>04.2</u> W	<u>09</u> / <u>1154Z</u>		
IPV on Board	<u>17</u> - <u>33.8</u> N	<u>86</u> - <u>02.2</u> W	<u>09</u> / <u>1239Z</u>		

Hydrophones:

No.	Depth (M)	Tape Rec. Channel	Ser. No.	Event	Date/Time (GMT)
1.	<u>508</u>	<u>1</u>	<u>0002</u>	Osc. Start	<u> </u> / <u> </u> Z
				Tape Start	<u>28</u> / <u>2232Z</u>
2.	<u>1119</u>	<u>2</u>	<u>0014</u>		
3.	<u>2341</u>	<u>3</u>	<u>0011</u>	Delay Interval Set	<u>0</u> d <u>2</u> h <u>40</u> m
				Delay Cycles Set	<u>16</u>
4.	<u>4053</u>	<u>4</u>	<u>0008</u>	Duty Cycle	<u>1</u> : <u>1</u>
5.	<u>4358</u>	<u>5</u>	<u>0015</u>	On Time	<u> </u> m
6.	<u>4450</u>	<u>6</u>	<u>0013</u>	Off Time	<u> </u> m

Bottom 2465 f corrected
4509 mTime Code Sync 28/1200 Z 11/28/72
On Recovery 12/9/72 - 1322 Z
Time Code 11 d 01 h 22 min.

Figure 22a

DEPL. NO. 17

Recovery Aids

1. Acoustic Releases

Location	Mfr.	Model	Ser. No.	Chan. No.	Freq. kHz	Remarks
Upper	AMF	322	401	3	9	
Lower	AMF	322	403	5	11	

2. Timed Release

Location	Mfr.	Model	Ser. No.	Release Time			Set Time			Counter Set No.
				d	h	m	d	h	m	
Lower	Geodyne	855	0634	11	08	00	27	12	00	1328

Disarmed on Recovery 09 02 30

Red 293

Blue 1135

3. Radio Beacons

Location	Mfr.	Model	Ser. No.	Chan. Letter	Freq.	Remarks
Top Buoy	OAR	ST-206-1-100-PA	751	A	26.995	
RPM	OAR	ST-206-1-100-PA	752	C	27.095	
RPM	OAR	ST-206-12	534	D	27.145	

4. Flashers

Location	Mfr.	Model	Ser. No.	Remarks
Top Buoy	OAR	SF-506-1-100	288	
RPM	OAR	SF-500-1-100	343	

NOTES:

1. Channel 2 Gain Ckt. - Locked on 40 db gain.
2. Hydrophones 3 & 6 suspended by surgical tubing.

Figure 22b

Experiment CHURCH GABRO Area NW CARIBBEAN
ACODAC Sys- Mooring Freq.
tem No. IPV Ser. 2A3 Type Westinghouse Band 15 300 Hz
Hydrophone Type Westinghouse Weather Clear, Vis 25 mi, W 10K from South
Sea Conditions _____
Deployment:
Deployment Method RPM last DEPL. NO. 18

	Lat.	Long.	Date/Time (GMT)	Course (°T)	Speed (kts.)
Commenced Operations	<u>19</u> - <u>54.4</u> N	<u>84</u> - <u>50.5</u> W	<u>26</u> / <u>1400Z</u>	<u>000</u>	<u>0</u>
1st Gear in Water	<u>19</u> - <u>54.7</u> N	<u>84</u> - <u>50.0</u> W	<u>26</u> / <u>1415Z</u>	<u>000</u>	<u>1.0</u>
IPV in Water	<u>20</u> - <u>00.4</u> N	<u>85</u> - <u>00.4</u> W	<u>26</u> / <u>2231Z</u>	<u>045</u>	<u>0</u> (M)
Anchor Dropped	<u>20</u> - <u>00.4</u> N	<u>85</u> - <u>00.4</u> W	<u>26</u> / <u>2234Z</u>	<u>045</u>	<u>0</u>
Mooring Position	<u>20</u> - <u>00</u> N	<u>84</u> - <u>58.7</u> W	<u>26</u> / <u>2230Z</u>		

Recovery						Course (°T)	Speed (kts.)
Commenced Operations	_____	-	_____ N _____	-	_____ W _____ / _____ Z	_____	_____
Mooring Release	_____	-	_____ N _____	-	_____ W _____ / _____ Z	_____	_____
Mooring on Surface	_____	-	_____ N _____	-	_____ W _____ / _____ Z	_____	_____
Mooring on Board	_____	-	_____ N _____	-	_____ W _____ / _____ Z	_____	_____
IPV Release	_____	-	_____ N _____	-	_____ W _____ / _____ Z	_____	_____
IPV on Surface	_____	-	_____ N _____	-	_____ W _____ / _____ Z	_____	_____
IPV on Board	_____	-	_____ N _____	-	_____ W _____ / _____ Z	_____	_____

No.	Depth (M)	Tape Rec. Channel	Ser. No.	Event	Date/Time (GMT)
1.	595	1	2	Osc. Start	___/___Z
				Tape Start	29/1504Z
2.	1205	2	24		
3.	2426	3	15	Delay Interval Set	2 d 18 h 40 m
				Delay Cycles Set	400
4.	4137	4	20	Duty Cycle	1:1
5.	4443	5	22	On Time	m
6.	4535	6	27	Off Time	m
Bottom 2511 f 4593 m				Time Code Sync	1200 z 11/26/72

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DEPL. NO. 18

Recovery Aids

1. Acoustic Releases

Location	Mfr.	Model	Ser. No.	Chan. No.	Freq. kHz ₂	Remarks
Upper	AMF	322	399	1	9	
Lower	AMF	322	405	10	11	

2. Timed Release

Location	Mfr.	Model	Ser. No.	Release Time			Set Time			Counter Set No.
				d	h	m	d	h	m	
Lower	Geodyne	355	0653	13	08	00	25	18	00	1688

3. Radio Beacons

Location	Mfr.	Model	Ser. No.	Chan. Letter	Freq. Hz	Remarks
Top Buoy	OAR	ST-206-1 -100 PA	766	C	27.095	
RPM	OAR	ST-206-1 -100 PA	763	A	26.995	
RPM	OAR	ST-206-12	491	D	27.145	

4. Flashers

Location	Mfr.	Model	Ser. No.	Remarks
Top Buoy	OAR	SF-500-1 -100	342	
RPM	OAR	SF-500-1 -100	289	

Figure 23b

ACODAC DEPLOYMENT AND RECOVERY LOG

Experiment CHURCH GABRO Area NW CARIBBEANACODAC Sys-
tem No. IPV Ser. 2A4 Mooring Type compliant (UM) Freq. Band HzHydrophone Type ITC 8020 Weather Clear, windSea Conditions Sea State 3

Deployment:

Deployment Method RPM last Depl. No. 19

	Lat.	Long.	Date/Time (GMT)	Course (°T)	Speed (kts.)
Commenced Operations	<u>18</u> - <u>50.0</u> N	<u>79</u> - <u>48.5</u> W	<u>30</u> / <u>1755Z</u>	<u>267</u>	<u>0</u>
1st Gear in Water	<u>18</u> - <u>50.0</u> N	<u>79</u> - <u>46.3</u> W	<u>30</u> / <u>1821Z</u>	<u>267</u>	<u>0</u>
IPV in Water	<u>18</u> - <u>48.7</u> N	<u>79</u> - <u>52.5</u> W	<u>30</u> / <u>2120Z</u>	<u>240</u>	<u>12</u>
Anchor Dropped	<u>18</u> - <u>48.7</u> N	<u>79</u> - <u>52.5</u> W	<u>30</u> / <u>2120Z</u>		<u>0</u>
Mooring Position	<u>18</u> - <u>49.0</u> N	<u>79</u> - <u>52.7</u> W	<u>30</u> / <u>2240Z</u>		<u>0</u>

Recovery

	Lat.	Long.	Date/Time (GMT)	Course (°T)	Speed (kts.)
Commenced Operations	<u>18</u> - <u>50.2</u> N	<u>79</u> - <u>53.0</u> W	<u>15</u> / <u>1120Z</u>		
Mooring Release	<u>18</u> - <u>50.2</u> N	<u>79</u> - <u>53.2</u> W	<u>15</u> / <u>1146Z</u>		<u>0</u>
Mooring on Surface	<u>18</u> - <u>50.0</u> N	<u>79</u> - <u>52.0</u> W	<u>15</u> / <u>1159Z</u>	<u>090°</u>	<u>1</u>
Mooring on Board	<u>18</u> - <u>49.5</u> N	<u>79</u> - <u>51.7</u> W	<u>15</u> / <u>1545Z</u>	<u>230°</u>	<u>0</u>
IPV Release	<u>18</u> - <u>49.2</u> N	<u>79</u> - <u>51.3</u> W	<u>15</u> / <u>1555Z</u>		
IPV on Surface	<u>18</u> - <u>49.4</u> N	<u>79</u> - <u>51.5</u> W	<u>15</u> / <u>1702Z</u>		
IPV on Board	<u>18</u> - <u>49.4</u> N	<u>79</u> - <u>51.5</u> W	<u>15</u> / <u>1729Z</u>		

Hydrophones:

No.	Depth (M)	Tape Rec. Channel	Ser. No.	Event	Date/Time (GMT)
1.	<u>966</u>	<u>1</u>	<u>001</u>	Osc. Start	<u> </u> / <u> </u> Z
				Tape Start	<u>30</u> / <u>2310Z</u>
2.	<u>1576</u>	<u>2</u>	<u>004</u>		
3.	<u>2757</u>	<u>3</u>	<u>005</u>	Delay Interval Set	<u> </u> d <u>2</u> h <u>40</u> m
				Delay Cycles Set	<u>16</u>
4.	<u>4410</u>	<u>4</u>	<u>006</u>	Duty Cycle	<u>1</u> : <u>1</u>
5.	<u>4715</u>	<u>5</u>	<u>012</u>	On Time	<u> </u> m
6.	<u>4806</u>	<u>6</u>	<u>009</u>	Off Time	<u> </u> m
	Bottom 2642 f			time code sync	<u>1200 Z 11/30/72</u>
	4833 m			on recovery	<u>1746 Z 12/15/72</u>
				time code	<u>15 d 5h 46m</u>

Figure 24a

DEPL. NO. 19

Recovery Aids

1. Acoustic Releases

Location	Mfr.	Model	Ser. No.	Chan. No.	Freq. kHz	Remarks
Upper	AMF	322	400	2	9	
Lower	AMF	322	404	6	11	

2. Timed Release

Location	Mfr.	Model	Ser. No.	Release Time			Set Time			Counter Set No.
				d	h	m	d	h	m	
Lower	Geodyne	S55	0648	16	08	00 _R	29	10	45 _R	1621

Disarmed on recovery 12/15/72
time 1530 Q
red 170 should have read:
black 1539 Black 1555 Unit was slow
by 4 hrs.

3. Radio Beacons

Location	Mfr.	Model	Ser. No.	Chan. Letter	Freq. mHz	Remarks
Top Buoy	OAR	ST-206 1-100PA	768	D	27.145	
RPM	OAR	ST-206- 1-100PA	765	B	27.045	
RPM	OAR	ST-206- 12	499	A	26.995	

4. Flashers

Location	Mfr.	Model	Ser. No.	Remarks
Top Buoy	OAR	SF-506- 1-160	287	
RPM	OAR	SF-500- 1-100	346	

- NOTES: 1. Telemetry from RPM indicates all channels with data except #1; all voltages normal
2. IPV check on recovery indicates all voltages normal.

Figure 24b

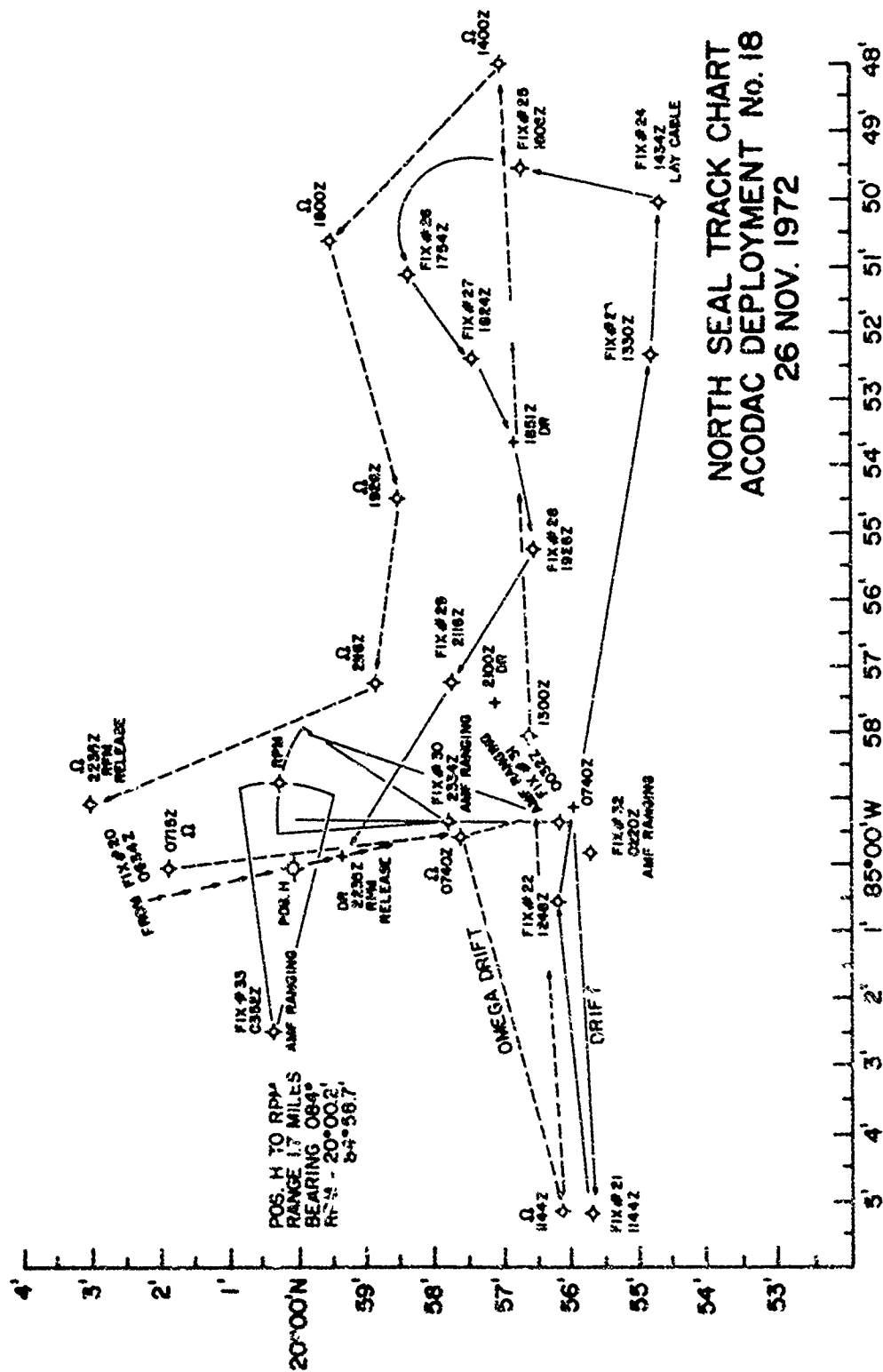


Figure 25

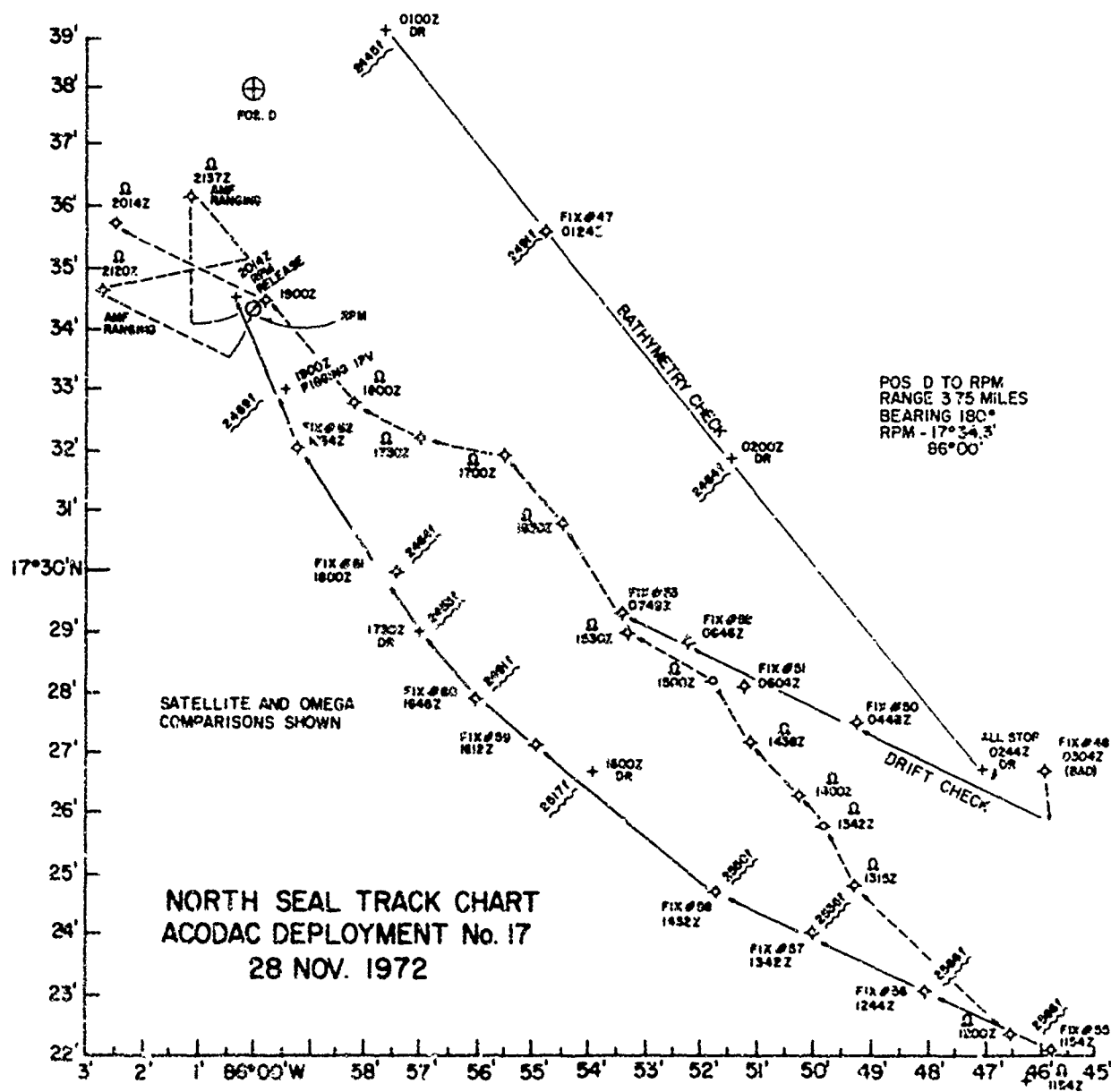
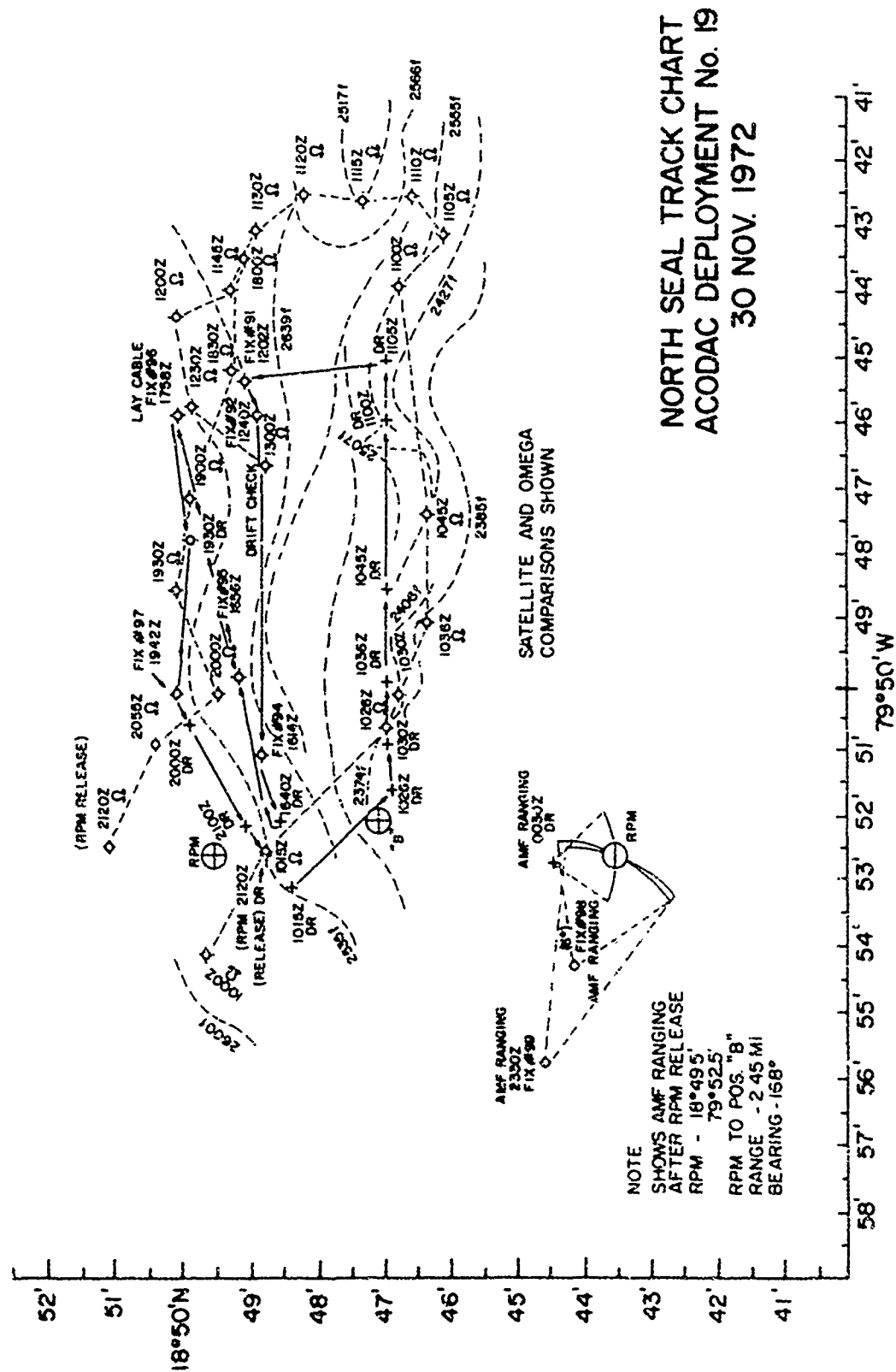
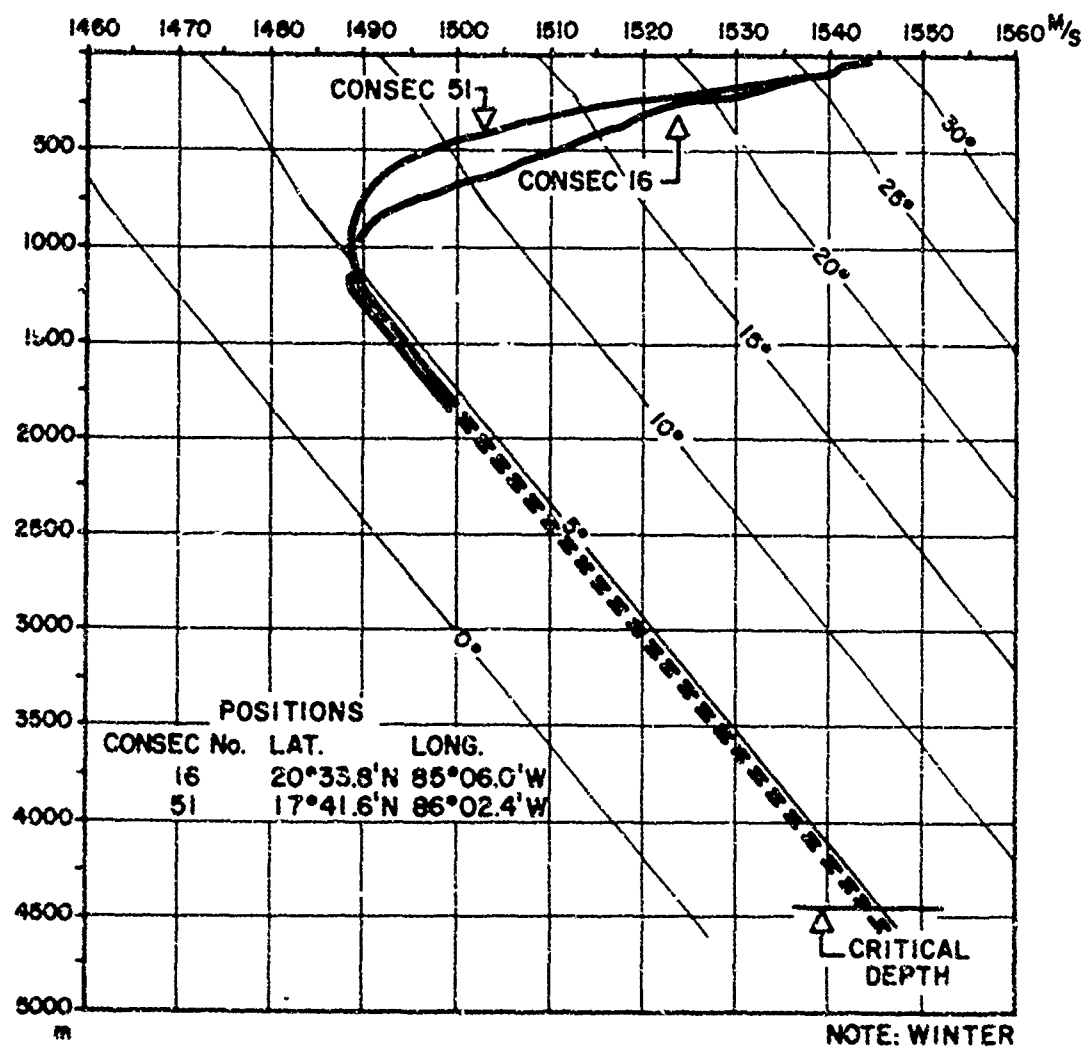


Figure 26





Sound Velocity Profiles
Derived From Temperature Profiles,
(Assuming Standard Salinity Profile)

Figure 28

number 5 were as follows: deployment no. 17 (Point D) - 4358 meters; deployment no. 18 (Point H) - 4443 meters; deployment no. 19 (Point B) - 4715 meters. The "winchless" method at deployment of the compliant array is illustrated in Figure 29.

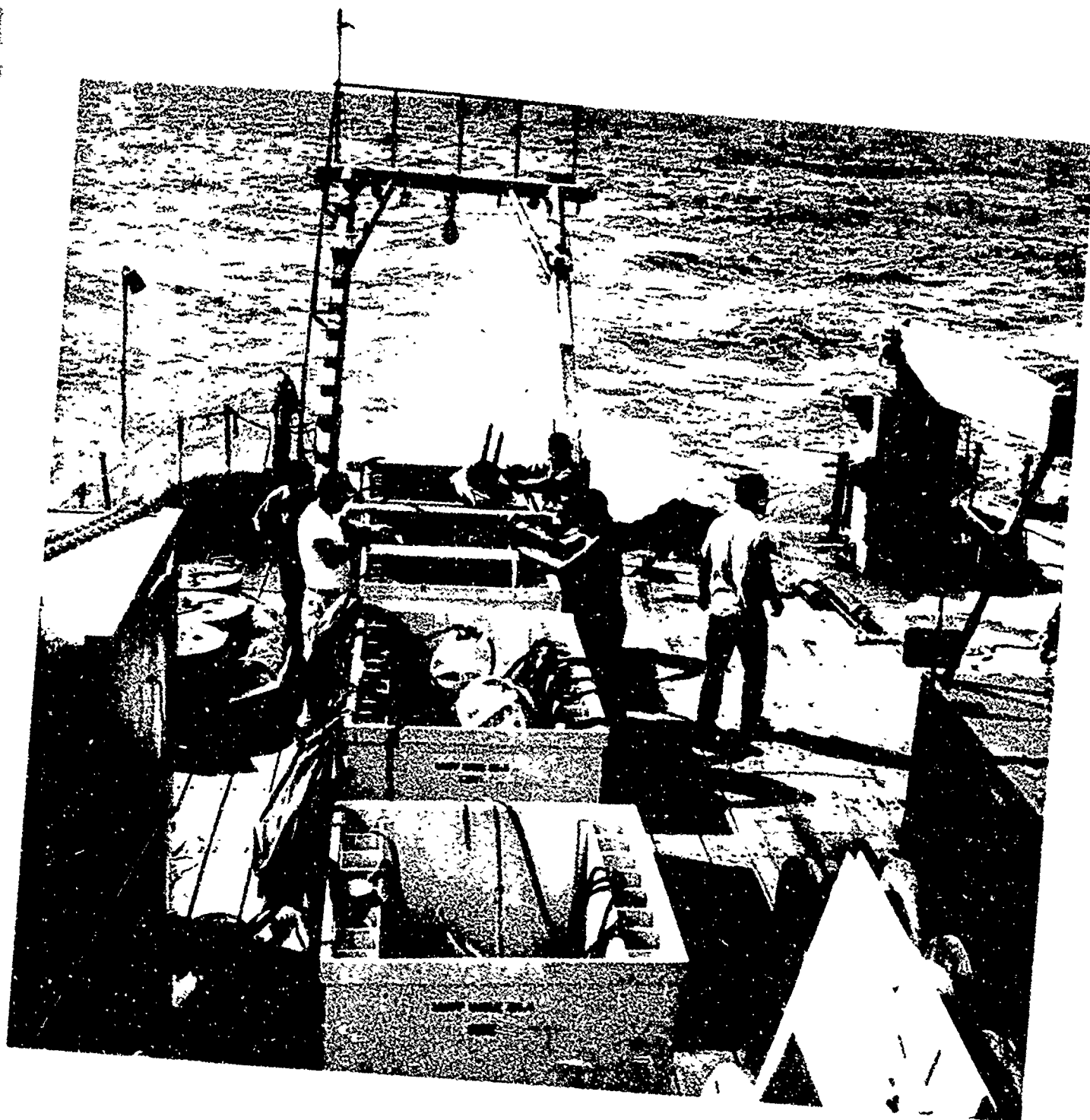
Deployment and recovery times are summarized below:

Position	Deployment No.	Deployment Time	Recovery Time
D	17	8 hr 10 min	3 hr 03 min
H	18	8 hr 19 min	-----
B	19	2 hr 59 min	3 hr 46 min

The system at Point H was not recovered during the exercise. A detailed acoustic search for the AMF release transponders was conducted from 10 through 13 December. In addition, on 12 and 13 December VP aircraft conducted a visual and radio search (for the OAR radio beacon) in the area, concentrating on the NW octant centered at Position H, and extending past the Yucatan Straits, but also covering the entire area within 15 miles of Position H. The track chart for the acoustic search is shown in Figure 30. The entire search was fruitless, leading to the conclusion that the mooring was no longer where it was deployed. This conclusion was confirmed by the subsequent location and recovery of the entire mooring in the vicinity of Fort Lauderdale, Florida. The acoustic release had not fired; the timed release had fired, but indicated the correct number of counts for a scheduled firing on 13 December at 1200Z. Evidence from the acoustic record shows that the most probable time of breaking loose was on 7 December at about 0100Z. The most likely cause of failure was chafing of the lower section of nylon rope between the anchor and release. It is possible that the failure to burden the anchor smoothly onto the mooring during deployment could have contributed to the parting of this section of line. For a report by Texas Instruments of the failure see Reference (28).

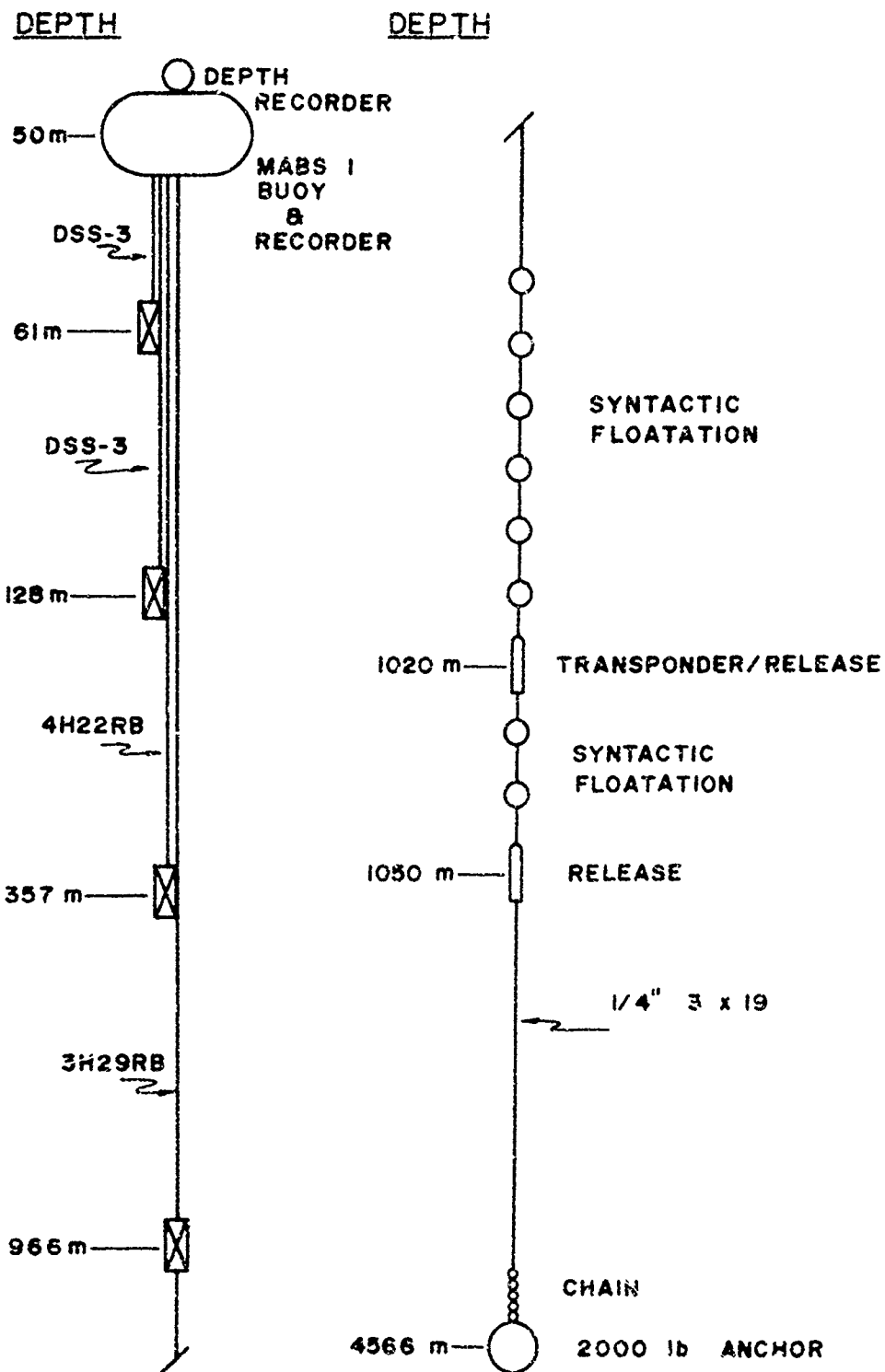
2.1.2 THE MOORED ACOUSTIC BUOY SYSTEM (MABS)

MABS is a calibrated, ship transportable system for the recording of ocean ambient acoustic noise and other underwater acoustic signals. For a description of MABS see Reference (10). As shown in Figure 31, for this exercise it consisted of four hydrophones suspended at nominal depths of 61 meters, 128 meters, 357 meters, and 966 meters. These hydrophones were suspended below a sub-surface buoy (~50 meters) which contained the electronics and logics of the system. The sub-surface buoy was an international-orange and yellow ellipsoid with dimensions 6 feet by 3.5 feet. The buoy with its integral instrumentation capsule weighed 2200 lbs. and was 1900 lbs. buoyant when submerged in sea water. It is equipped with pad-eyes for lashing to the deck. It also has two flashing lights and a radio beacon to aid in recovery. At the terminus of the 915 meters of electrical cable was approximately



Compliant Array Ready for Deployment

Figure 29



MABS Configuration

Figure 31

3,660 meters of 3/8" steel wire connected to the electrical by an AMF acoustic release and transponder in series. The anchor was a 2220 lb. clump.

A five hydrophone single cable array was to have been used during the exercise; however, due to manufacturer's delays this array was not available. The make-shift four hydrophone array was used as back-up. This array had separate cables to each hydrophone. The cables were married using tie-wraps and only the areas in the vicinity of the hydrophones were faired. The hydrophones with their associated cable were calibrated against a reference hydrophone at NUSC's Millstone Quarry during the last part of October 1972.

The hydrophones used were NUS Corporation LM-3 deep sea hydrophones; see Reference (20). These were chosen because of their relatively flat frequency response between 10 Hz and 20 kHz and also because they have stable sensitivity over the extremes of pressure and temperature found in the ocean. A representative terminal sensitivity of one of these hydrophones including the internal 28 lb preamplifier and cable is -155 db/1 volt for sound pressure field of 1 uPa. The hydrophones are not generally recalibrated after an exercise because of the expense involved. However, a recalibration would be conducted if warranted by an obvious defect. The calibrations of these hydrophones have been found to be generally invariant in the past.

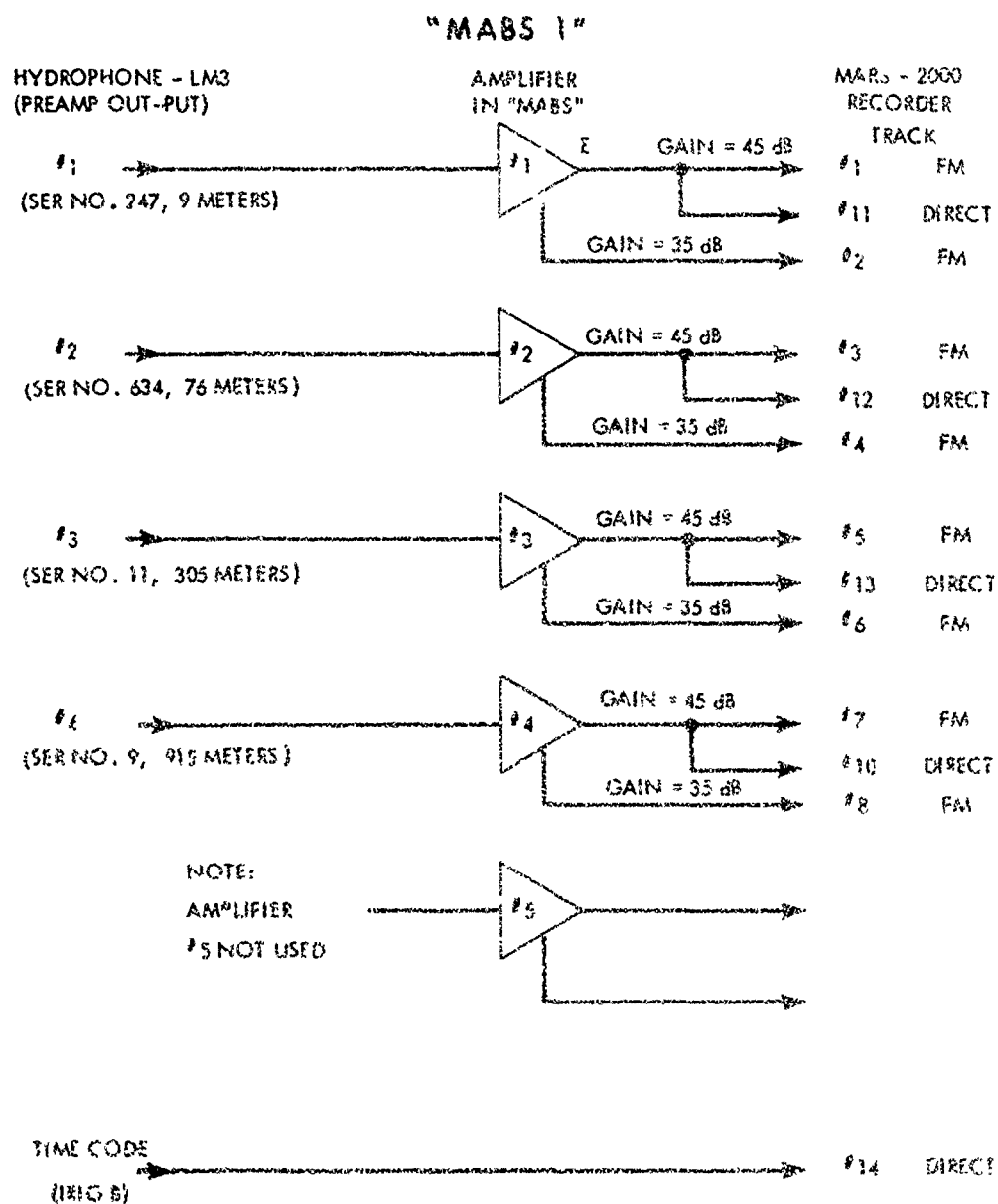
The received acoustic signals are fed onto the instrumentation capsule where they are recorded for 30 seconds every 15 minutes. Before being recorded the signals are amplified (+45 db for Hi-Gain channels and +35 db for Lo-Gain channels) as indicated in Figure 32. The recorder used is the Astroscience MARS 2000 unit using a speed of 1 7/8 IPS. This recorder has a modified carrier frequency for extended band on the FM channels.

Calibration signals injected at the input of the amplifiers were recorded for 30 seconds every four hours; see Figure 33. These calibration signals consisted of wide-band pseudo-random noise and a 1 kHz sine-wave tone.

The system deployed well except for the instrumentation sphere overturning for a short while. This later proved to be a major problem because the shallowest hydrophone parted electrically and rendered no data. Total deployment on 3 December 1972 took five hours and 24 minutes with the array in 4566 meters of water at 19°10.87'N, 76°49.9'W. A Benthos depth recorder attached to the buoy showed depth changes from 40 meters to 100 meters during the recording period. The array was retrieved on 12 December in six hours. The retrieval was complicated by some floats fouling about the ship's bow thruster.

Data Quality

The quality of data recorded by MARS is in general good. It

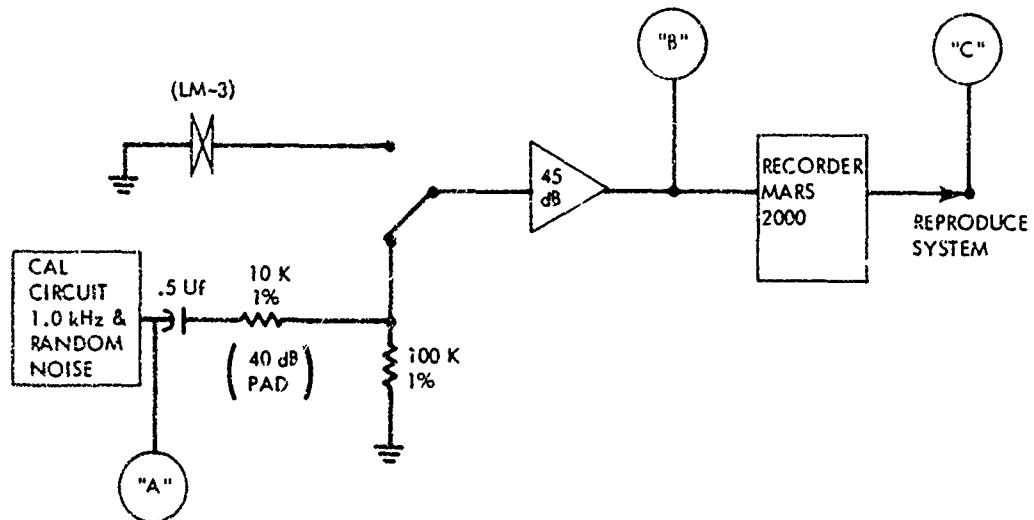


MABS Signal Processing Scheme

Figure 32

MABS 1 SYSTEM

11-29-72



CAL SIGNALS (dB // 1.0V)

	"A"	"B"	"C"
1.0 kHz	- 12.5 dB	- 8.0 dB	- 8.0 dB
RANDOM NOISE (BROAD-BAND)	- 12.5 dB	- 8.0 dB	- 10.25 dB
COMBINED SIGNALS (BROAD-BAND)	- 10.25 dB	- 5.25 dB	- 6.25 dB

MABS Calibration Scheme

Figure 33

recorded data for eight days and eleven hours. The shallowest hydrophone was inoperative and the deeper units were subject to intermittent low-frequency strum of 3.25 Hz which generally could be filtered out and did not distort higher frequency data. It is felt that the strum would be all but absent if the single-cable faired array had been used.

2.1.3 TELEMETERING ACOUSTIC BUOY SYSTEM (TABS)

The Telemetering Acoustic Buoy System (TABS) used during this exercise consisted of two hydrophone faired cable array suspended below a telemetering spar buoy which transmitted the received acoustic signals via R.F. link to SANDS where the data were demodulated and recorded on magnetic tape; see Figure 34. TABS was deployed for a ten hour period in the vicinity of position C on 7 December 1972 for the aircraft SUS run.

The hydrophones, which were at depths of 244 meters and 396 meters, were NUS Corporation LM-3 units that have been previously described in the MABS section of this report. The hydrophones were calibrated against a reference hydrophone in July 1972 at NUSC's Dodge Pond Calibration Facility. Prior to deployment the system was calibrated by injecting single frequency sine-wave signals of known levels at the center frequency of all the 1/3-octave bands of interest at the input to the transmitting buoy. These signals were recorded on magnetic tape as received throughout the entire receiving system. In this manner the whole system was calibrated.

TABS took less than one hour to deploy and one hour to retrieve. A radio beacon and flashing light attached to a satellite buoy facilitates recovery.

The acoustic signals received by the hydrophone of TABS were sent to SSQ-41 SONOBUOY transmitters in the spar buoy where they are modulated transmitted to the SANDS; see Figure 35. SANDS received the signals on an ARR-52 SONOBUOY receiver (High Output) where they were demodulated and then were attenuated by 25 db. The signals were then split into High and Low Gain sections (10 db difference) at the input to separate Ithaco amplifiers. From the amplifier the signals were recorded on magnetic tape (Ampex CP-100 recorder). The signals were recorded FM at 3 3/4 IPS. Signals from the reproduce mode of the recorder were then fed to 1/3-octave filters and the outputs monitored on an 8 channel Sanborn graphic recorder.

The receiver and recorder calibration systems are shown schematically in Figure 36.

TABS performed quite well during the first part of the SUS run; however, during the last two hours of the run the system became quite noisy. It has not been determined at present whether this noise was water-borne (strum, etc.) or RF interference.

Naval Underwater Systems Center
NP24 - 49221 - 4 - 73

Official Photograph

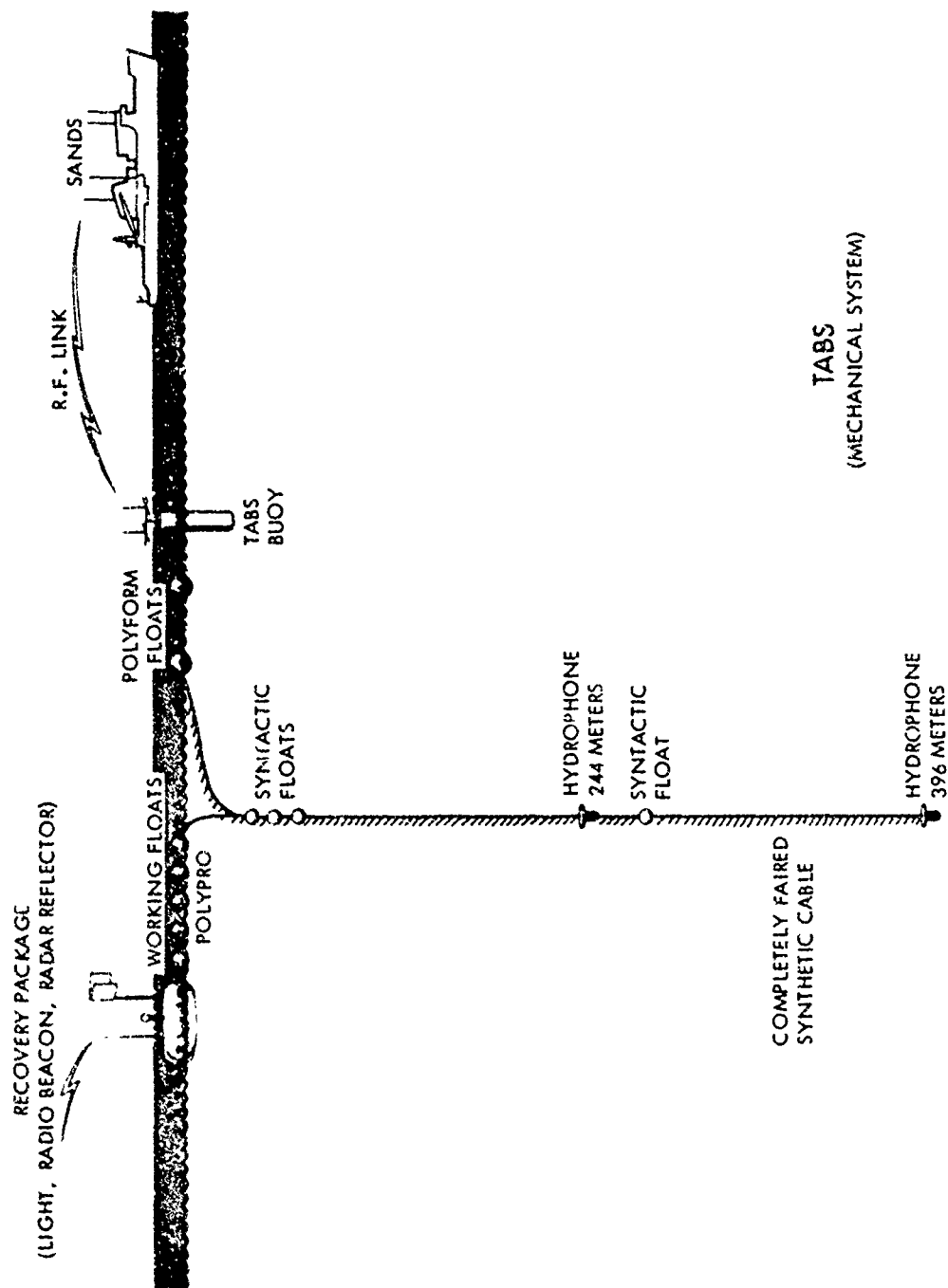
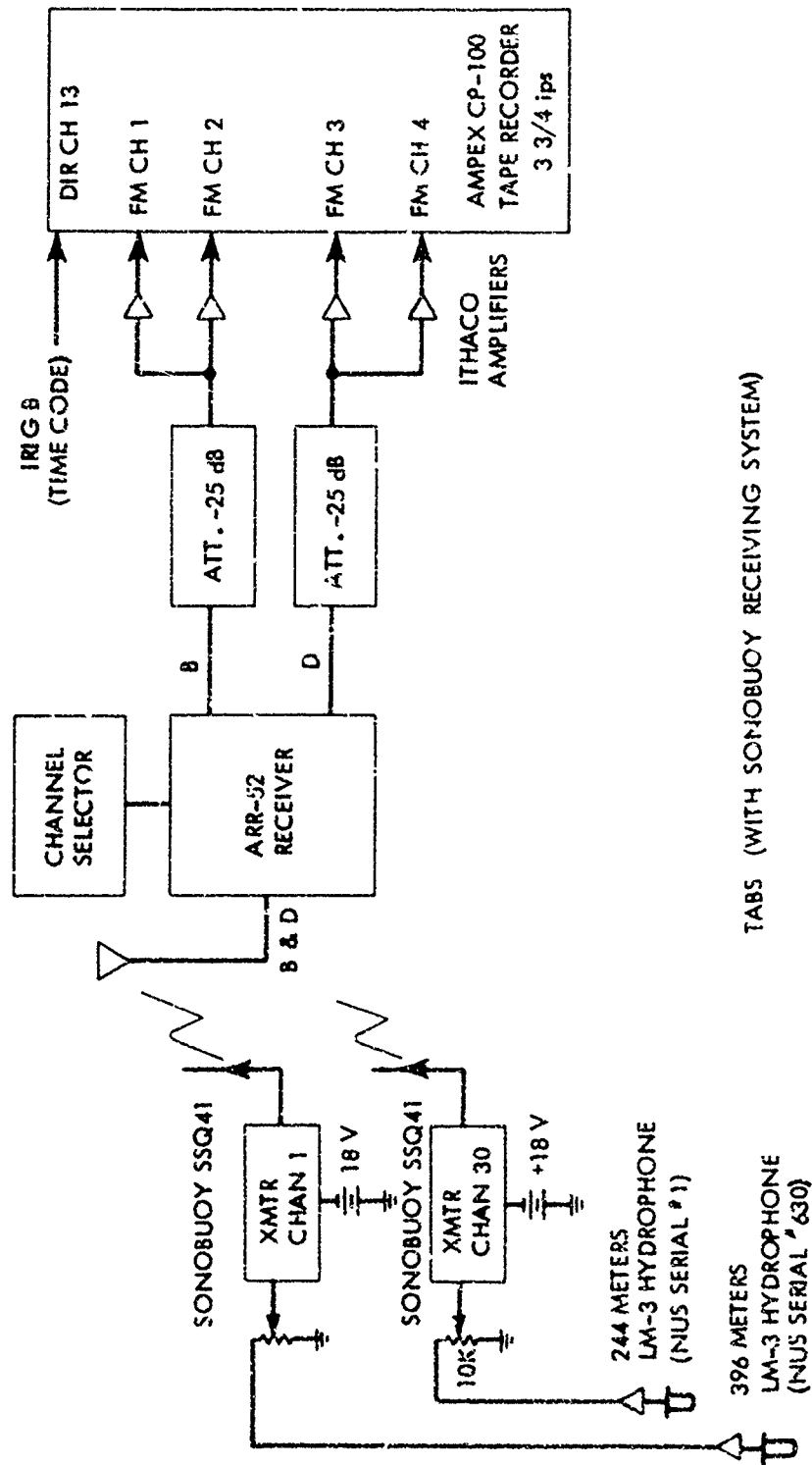
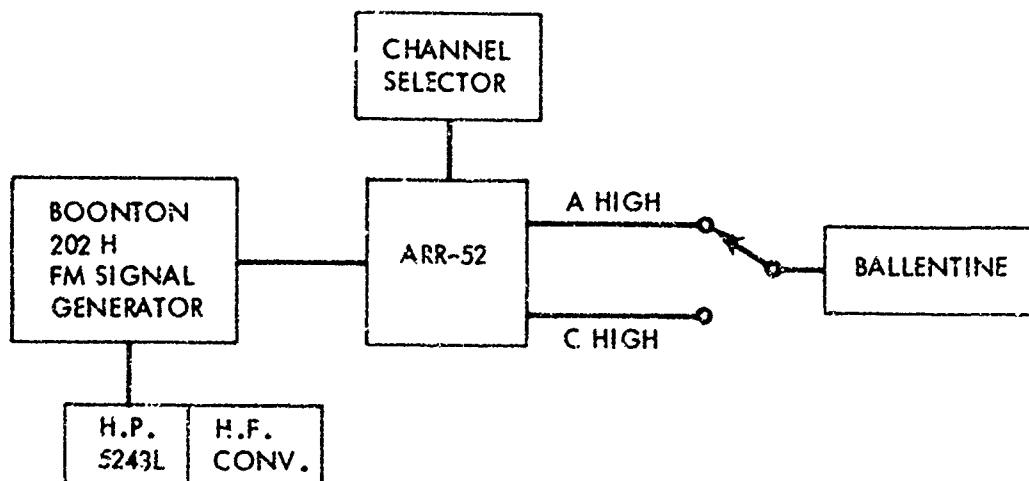


Figure 34

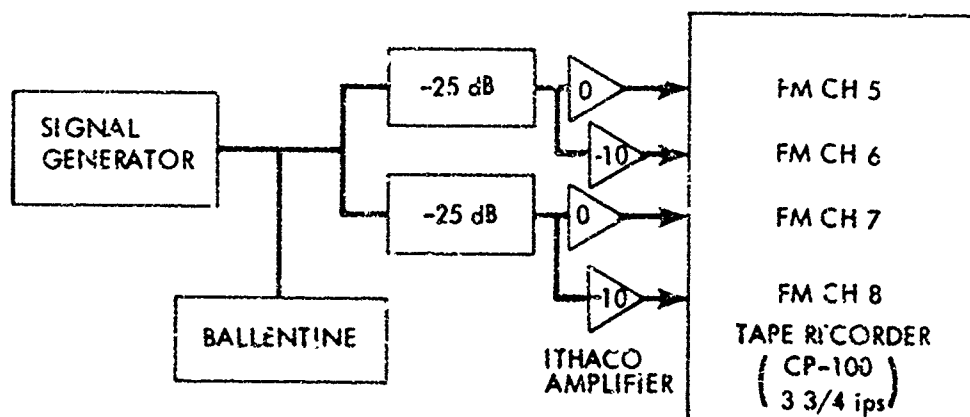


TABS (WITH SONOBUOY RECEIVING SYSTEM)

Figure 35



RECEIVER CAL SYSTEM



RECORDER CAL SYSTEM

TABS Calibration System

Figure 36

2.1.4 VLAM

A. General

A general overview of the major components of the vertical line array measurement system (VLAM) is presented in Figure 37. For a description of the VLAM system see Reference (1), from which figures 37-42 are taken. These components comprise a general-purpose multi-channel acoustic data gathering system.

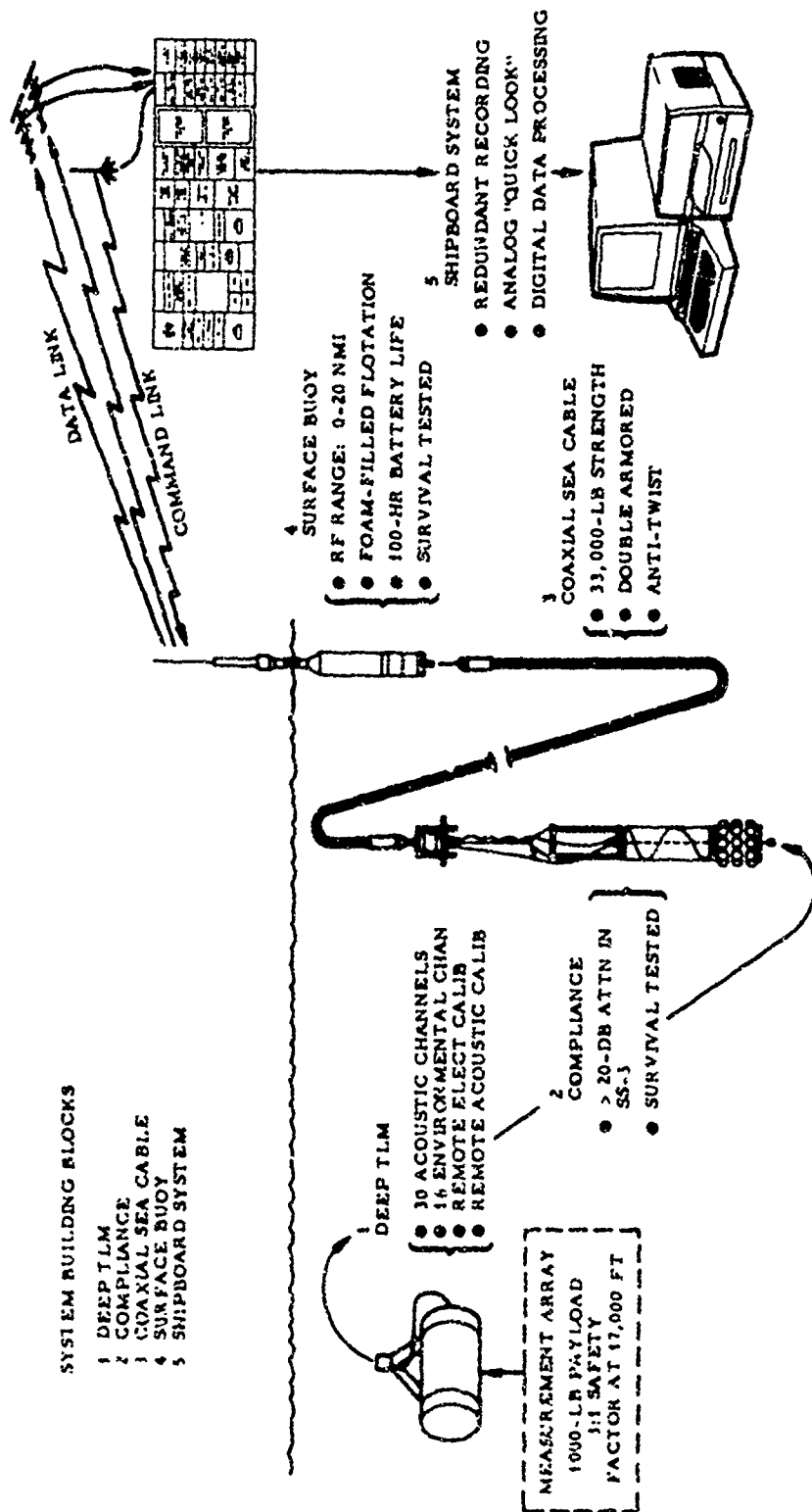
VLAM consist of an array of acoustic sensors, the deep telemetry system, a set of deep sea coaxial cables, hydrodynamic decoupling mechanisms, surface support buoys, an RF dual diversity data and command link, and a complete shipboard receiving, recording, and on-line processing system. These basic system elements may be thought of as building blocks and may be used in any combination required for a specific measurement mission. This system is deployed from the surface support buoy.

B. In-Water System

(1). General

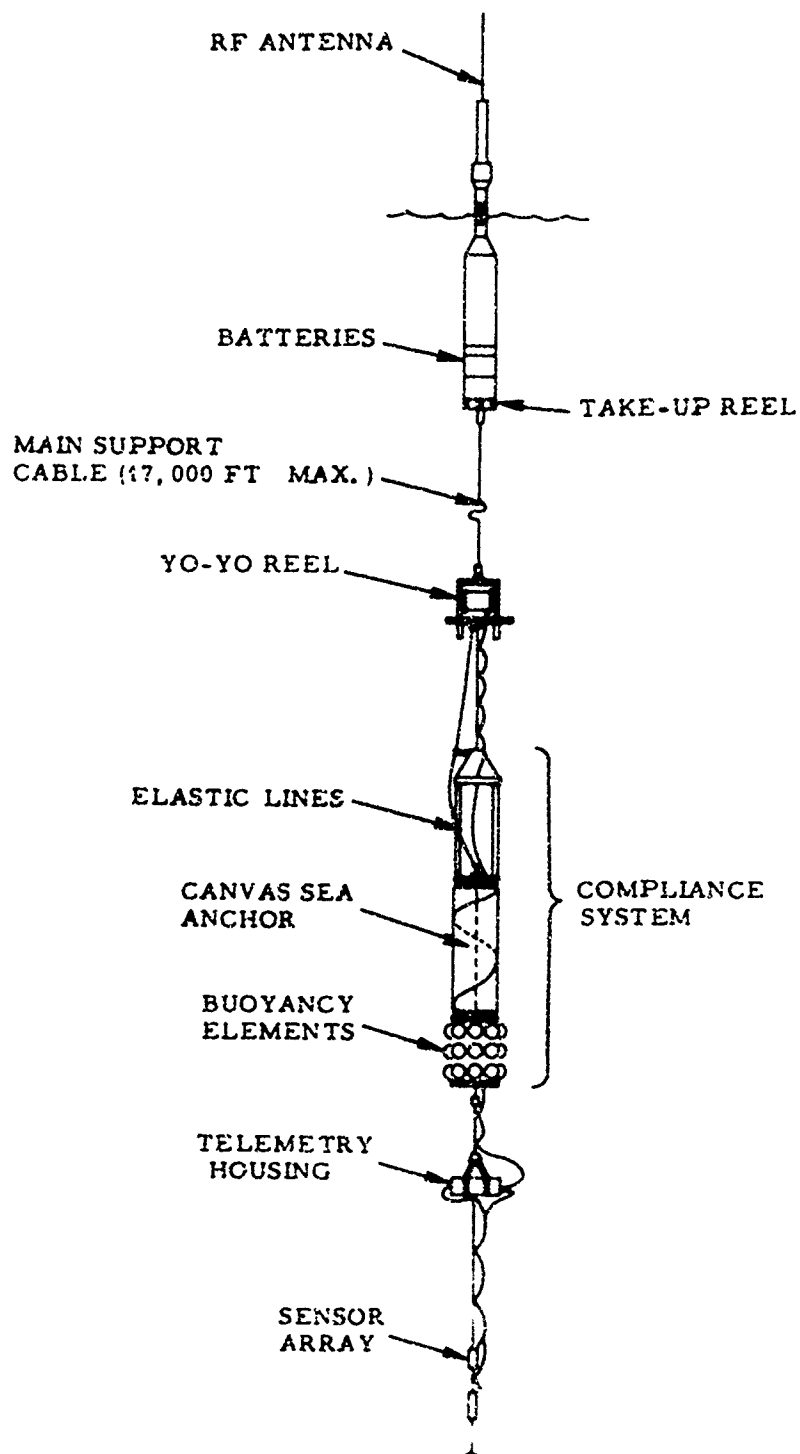
The deployed in-water system of VLAM is shown in Figure 38. It has the sensor array, which has 26 acoustic hydrophones, three two-axis tilt sensors, three high-frequency accelerometers, a velocimeter, a current sensor, depth sensor and three compasses. In addition, there are the other sub-systems that deploy the sensor array and handle the data up through the RF telemetry link to the ship board electronics.

- (2). The hydrophone module is a stainless-steel assembly which houses the hydrophone and its preamplifier. The phono, of lead zirconian titanate, is a two-element acceleration balanced unit suspended by a rubber isolation within the module. The low-noise preamplifier protected within its own pressure vessel is located adjacent but out of acoustic view of the hydrophone. Connections to the preamplifier and hydrophone are via Marsh-Marine connectors. The entire module is covered with a rubber shield to reduce flow noise.



Major Components of VLAN System
(From Reference (1))

Figure 37



VLAM In-Water System Fully Deployed
(From Reference (1))

Figure 38

Hydrophone parameters follow:

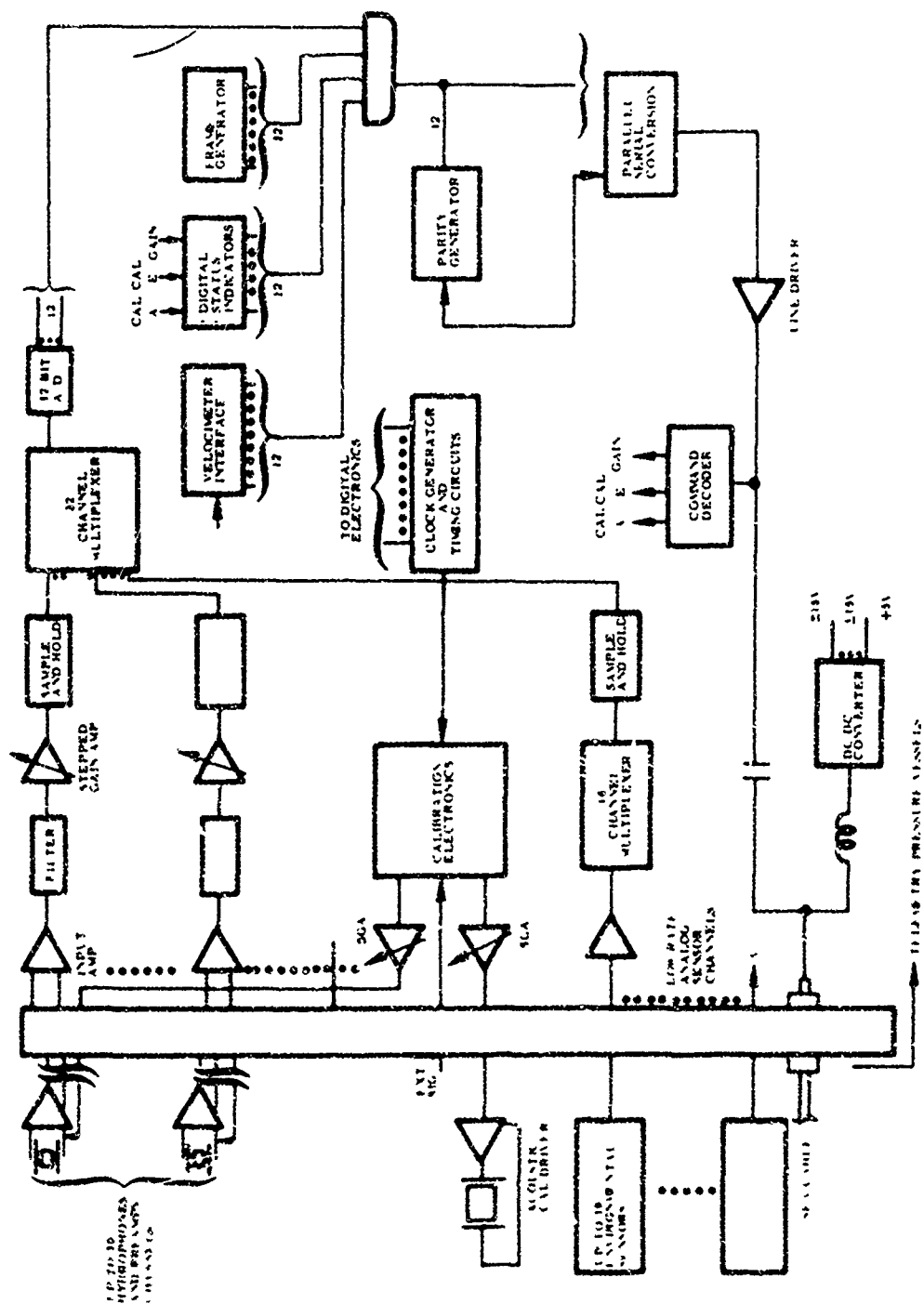
*Sensitivity	-90 dbv/ μ b
*Bandwidth	2 Hz to 5 kHz
*Acceleration Balanced	≥ 40 db cancellation due to vertical and/or horizontal motion
*Directionality	Omnidirectional all planes up to $75 f_0$ (≤ 0.1 db) ± 1 db up to 5 kHz
*Hydrophone Module Directionality	Omnidirectional all planes up to $75 f_0$ (≤ 0.1 db)
*Depth Sensitivity	≤ 1 db from 0 to 8000 psi
*Hydrophone to Hydrophone Amplitude and Phase Uniformity	Series opposing output ≥ 46 db down from series aiding output in frequency band up to $75 f_0$

(3). Deep Telemetry

A 17,000 foot coaxial sea cable and a 20 mile radio link serve to connect the deep sensors with a surface-tending vessel. The system is versatile in that various combinations of cables and RF links are provided. The system can be deployed from near surface to 18,000 feet, and can be suspended either from a buoy containing the radio equipment or directly from a tending vessel, in which case only the cable link is employed. A diagram of the deep telemetry electronics are shown in Figure 39.

The system is bidirectional, with commands being sent to the deep telemetry unit (DTU) from the tending ship, and data transmitted from the DTU. Power is also multiplexed on the sea cable with all power being supplied from either the buoy (when an rf link is used), or the ship (in the case of a direct cable link).

The basic data telemetry consists of a 32 channel analog multiplexing and A/D system which will accommodate up to 30 high-rate analog hydrophone inputs. The 32nd channel is further submultiplexed to handle low-rate analog sensor inputs. In addition, the telemetry accepts low-rate digital sensor inputs directly. State-of-the-art electronics are used throughout to maintain a total system accuracy of better than 0.1 db.



Deep Telemetry Electronics
[From Reference (1)]

Figure 39

The versatility of the system is greatly increased by the cross-strapping provided, allowing the maximum number of channels to be used at the basic sampling rate, or fewer channels to be used at correspondingly higher sampling rates. Low rate and high rate channels can be intermixed to obtain maximum system efficiency.

After multiplexing, all signals are converted to a serial digital 12-bit format, with a 13th parity bit added to every data word. This serial data stream is then transmitted at a bit rate of about 1 MHz over the cable and rf links. At the receiving end, every received data word is checked for parity and sync errors, with the error rate decoded and printed out in real time, on-line. Throughout the entire data transmission and data recording path, the specified error rate of 1 bit error per 1 million bits transmitted has been exceeded in the field, with the typical error rate being about 0.3×10^{-6} .

The command link is a 4-tone coded system and allows for 15 separate commands. Commands are generated onboard ship and are decoded both at the surface buoy and the DTU. The commands provided include gain change (all hydrophone channel gains are changeable, with 2 gains being provided), enable electrical calibration, enable acoustic calibration, change rf signal strength, and turn system on and off.

(4). Compliance System

The compliance system is designed to provide isolation from both vertical motion and motion-induced flow noise sufficient to prevent masking of data for all states encountered up through Sea State 3.

The system, as depicted in Figure 38, is composed of three basic elements:

- (1) Spring (twelve 1 1/8 inch diameter Natsyn rubber rods, 36 feet in length with a spring rate of 50 lb/ft).
- (2) Mass (5 foot diameter by 20 foot long sea anchor entrapping water mass of approximately 800 slugs).
- (3) Subsurface float to establish proper spring rate by adjusting static load bias.

(5). Coaxial Sea Cable

Four lengths of cable currently exist; one each of 12,000 feet and 17,000 feet and two of 3000 feet.

Equalization or reshaping of the digital data train is performed by a circuit card in either the buoy or the shipboard electronics, depending upon whether an rf-link or a direct-cable link is utilized. A special "equalizer" program has been written that will permit rapid implementation for any cable length.

Actual array depth is adjusted by reeling a predetermined amount of sea cable onto the yo-yo cable reel (Figure 38). This reel will accommodate up to 3000 feet of cable, thereby permitting a depth adjustment of between 0 and 3000 feet for any length of sea cable. A brief VLAM cable specification follows.

Diameter	0.65 inches
Weight	0.61 lb/ft in air 0.49 lb/ft in water
Breaking Strength	33,000 lbs
Attenuation at 1 MHz	1.5 db/1000 feet
Double armored, antitwist	

(6). Surface Buoy and RF Link

a. Surface Buoy

The surface buoy depicted in Figure 38 is designed to fully support the wet system for all cable lengths from 3000 ft. to 17,000 ft. Major features include a dual diversity rf-data transmission system and command receiver, a pneumatically operated telescoping antenna, battery packs for both the deep telemetry unit and the rf system, radar transponder and blinking strobe recovery aids, a pneumatic ballasting system, and a pneumatic battery equalization system. In addition to the buoy proper, there are three bolt-on additional buoyant sections to provide additional displacement for longer cable lengths; i.e., 8000-, 12,000-, and 17,000-ft. coaxial sea cables. These additional sections are used in lieu of a single large ballast chamber to preclude the possibility of losing the entire system

due to inadvertent flooding of that chamber. The chamber was sized such that in the event the chamber is fully flooded, sufficient reserve buoyancy will exist to prevent loss of the system. Both the buoy and the add-on sections are filled with a closed cell foam to prevent loss due to any cause other than a catastrophic collision. That section of the buoy which pierces the air-water interface has been made as small in cross section as possible, yielding a buoy stiffness of 32 lb. per foot.

b. RF System

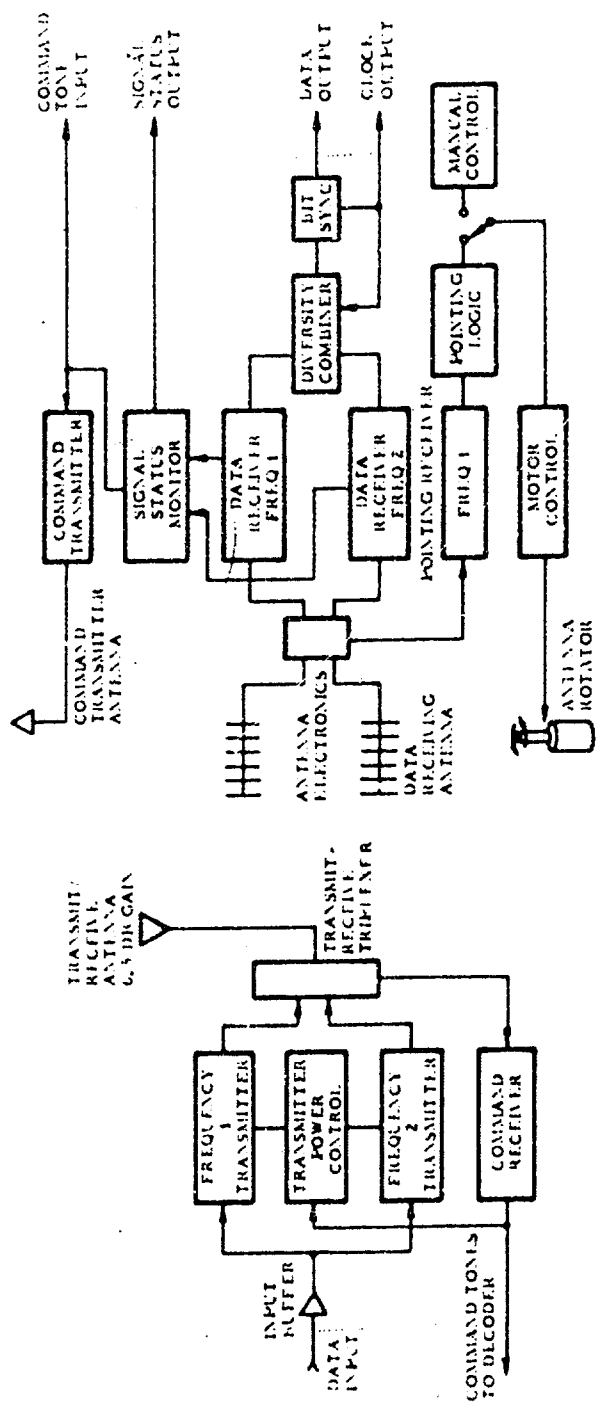
The VLAM rf system is a two way radio link between the buoy and the support ship; (1) digital data from the DTU is transmitted to the ship, and (2) command instructions, which can modify functions or operations in the buoy and DTU, are transmitted from the ship; see Figure 40.

The data channel has been designed to provide exceptionally error-free, reliable transmission. The system has a demonstrated ability (99.9 percent) to provide bit error rates of 1×10^{-6} over water paths of 18 to 20 miles. The system features dual-frequency diversity of 138 to 150 MHz with a diversity gain of 30 db. Modulation is FSK. Each of the two buoy transmitters can radiate either 50 or 350 watts of power, remotely commandable. Battery life is 25 to 100 hours depending on transmitter power.

At the ship, a fully automatic tracking antenna system employing two log periodic antennas affords a net antenna gain of 13 db.

The binary 4-tone command system operates at 220 MHz and employs narrowband frequency modulation. Like the data transmitters, it can operate at 50 or 350 watts. Its range is considerably in excess of the data link due to its inherent invulnerability to fade and multipath.

Like the DTU, the rf system should be considered a tool which can transmit large quantities of data at a high rate from an instrumentation system planted in the ocean to a monitoring ship. Since all rf components are spaced to operate from 130 to 170 MHz, frequencies may be shifted within this range if required.



BUOY COMMUNICATIONS EQUIPMENT

TRANSMITTER POWER 50/350 WATTS
 BATTERY LIFE 100/25 HOURS
 ANTENNA GAIN 6.5 DB
 OUTAGE RATE 20
 NAUTICAL MILES < 0.1, F. 2/1
 BIT ERROR RATE 10-6 MAX.

SHIPBOARD COMMUNICATIONS EQUIPMENT

DUAL DIVERSITY DATA RECEIVER
 ANTENNA GAIN: 11.0 DB DATA CHANNEL
 2.0 DB COMMAND CHANNEL
 AUTOMATIC ANTENNA POINTING SYSTEM
 COMMAND TRANSMITTER OUTPUT: 50-350 WATTS

VLAM Communications Equipment
 [From Reference (1)]

Figure 40

C. Shipboard Electronics

All the shipboard electronic equipment for VLAM is housed in a portable equipment van which houses nine relay racks, a 20 foot workbench, and a computer display console. A system flowchart is shown in Figure 41.

Data comes into the van from either the rf receivers or a direct cable link. The van input circuits then decode the digital data for presentation to the various analysis systems. In addition, the digital data is checked for both parity and synchronization errors, these error rates being automatically reduced to a hard copy record on-line. Every data word received is subject to these checks.

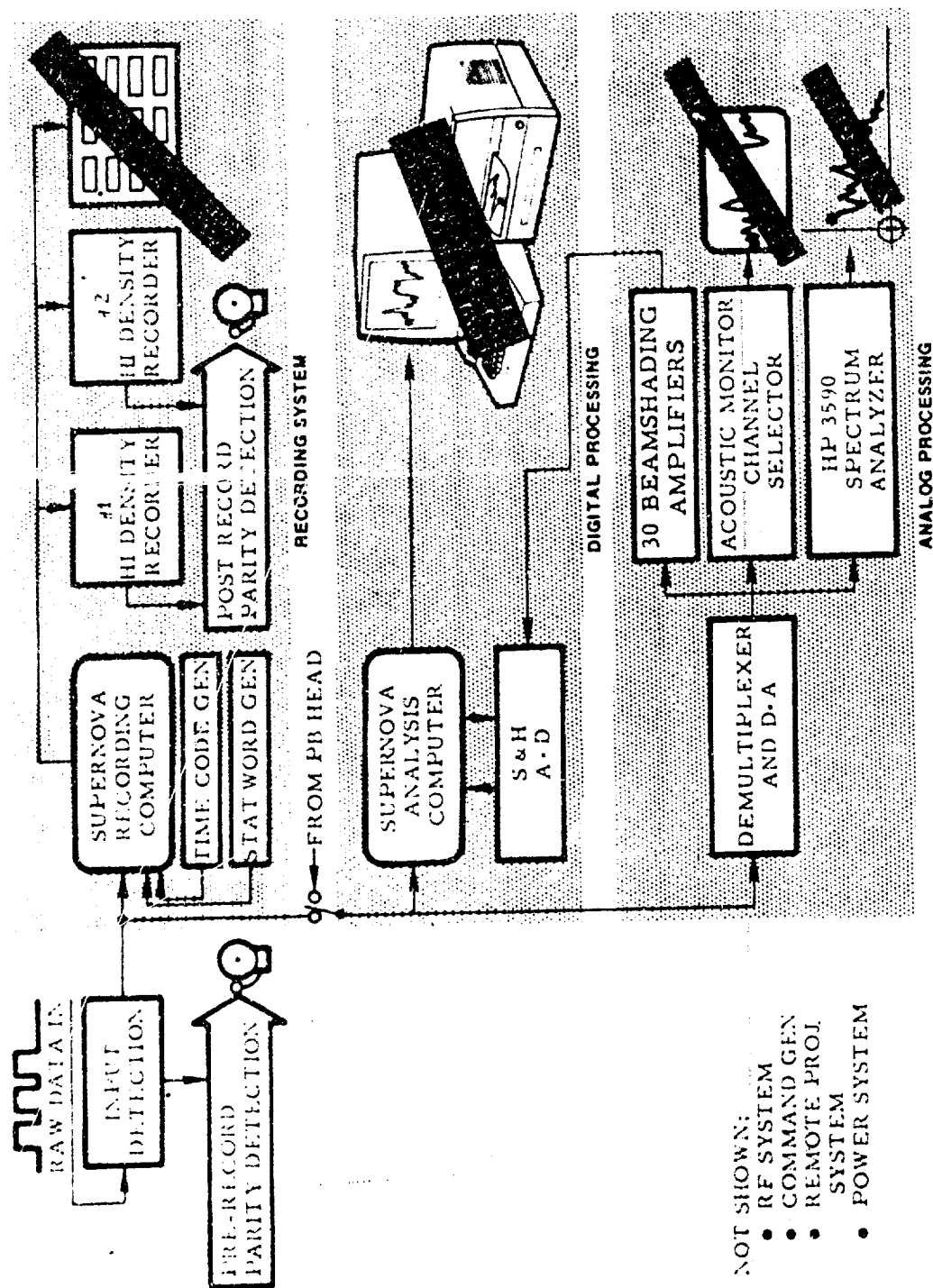
The acoustic information in the incoming data can be analyzed in either of two independent van systems. The primary analysis capability is provided by a 32K computer system which analyzes the digital data directly. Through a Tektronix CRT terminal and the interactive software provided, an analyst can:

- ° Perform amplitude and phase calibrations of every channel through built-in electrical and acoustic calibration electronics.
- ° Perform specialized narrowband or octave filtering of any channel.
- ° Subject any channel to FFT analysis.
- ° Form beams using either of the two VLAM arrays.
- ° Display and analyze array sensor outputs.

All of these analysis programs operate in real-time, and permit variable parameters such as filter bandwidths, integration times, beam steer angles, and output formats (various forms of graphical and tabulated results) to be selected on-line. A hard copy unit permanently records the data.

An independent parallel analysis system demultiplexes the data and presents simultaneously every channel in analog form. These signals can then be inputted to either a Hewlett Packard 3590 wave analyzer for spectral analysis or an oscilloscope for "quick look" quality assurance. A plotter is provided for a permanent record.

A second computer system in the van provides a continuous on-line, digital environmental sensor display. Twelve "nixie" tube banks continuously display the outputs of the array sensors. Included in the display are the outputs of three tilt stations (tilt plus direction), array depth, sound velocity, current direction and magnitude, battery voltage, and real-whole-time. This computer also serves as a data formatter for the recording system. Time code, the output of a



Shipboard Electronics Flowchart
[From Reference (1)]

Figure 41

van status switch bank, and ASC-II code from a teletype are all meshed together with the recrote DTU data in this computer and formatted for recording. Two recorders record the data simultaneously, providing a redundant capability. During the recording process, data is taken from the playback head and checked for errors identically as at the van input. Thus, good recorded data is assured at the time of recording.

D. Remote Projector Systems

Two independent VLAM projector systems exist. (See block diagram, Figure 42). Typically, these systems are used to project high level (88 to 90 db re μ b) pulses of acoustic energy at two frequencies. Each system is composed of an acoustic projector, sea cable (700 ft.), a high power linear driver, and one rack of equipment containing signal generation and timing equipment. Included on each projector is a depth sensor and a sound pressure level (SPL) monitor.

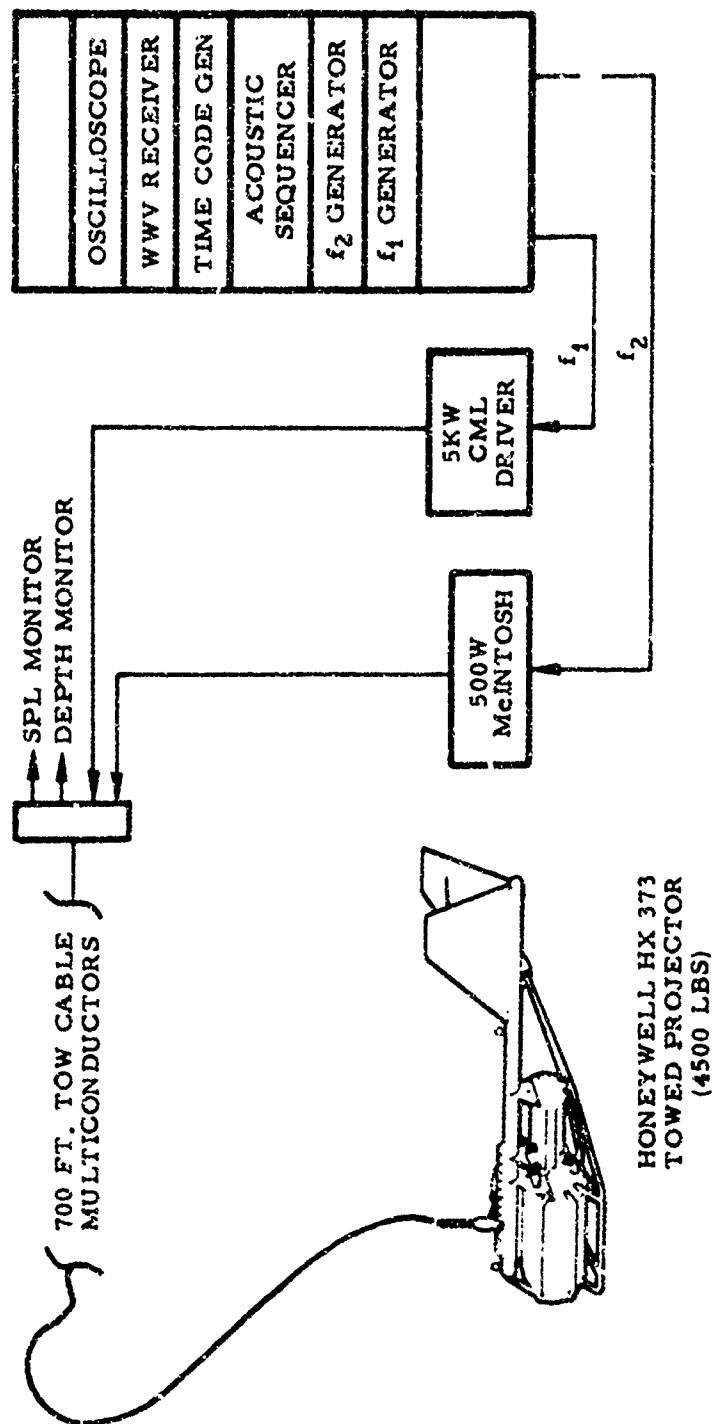
Pulse width is adjustable from 1 to 20 seconds and repetition rate from 1 to 100 seconds, both slaved to a digital clock. Since the clock can be synchronized with a WWV on-board receiver, it is possible to transmit pulses coherent within a few milliseconds. Since the system is linear, signals other than sine waves (i.e., FM slides or PRN) can be transmitted at well-defined intervals by substituting the proper signal source.

Specifications for the acoustic projector are as follows:

Source level	90 db re μ b at 2 operating frequencies, simultaneously
Operating Frequency	11 f_0 and 44 f_0
Operating Depth	To 500 feet
Maximum Towing Speed	5 knots
Weight (projector)	4500 lbs
Electronics	Single rack and drivers
Power Consumption	5 kw (1-kw output power)

E. Performance

During the exercise all systems operated satisfactorily for the deep deployment, with the exception of four hydrophones. The data from these four hydrophones were degraded because of leaky connectors. The beam forming results however, are not appreciably degraded by the elimination of these four hydrophones.



Remote Acoustic Projector System
[From Reference (1)]

Figure 42

The second planned deployment at a shallow depth was cancelled because the sea was too rough for deployment during the four day (10-13 December) period remaining.

A total of twenty six data tapes or sequences were made during the deep deployment. Each tape represents 105 minutes of continuous recorded data. A summary of data obtained is given in Table V together with a notation of errors noted. Only one tape (record No. 7-2-5) is completely unusable.

For further information on system performance and data output from the CHURCH GABBRO exercise, see References (2) and (24).

2.1.5 AN/SSQ-57A Sonobuoys

On 4 and 5 December, modified and unmodified AN/SSQ-57A sonobuoys were used to collect ambient noise and propagation loss data from aircraft in conjunction with a special aircraft data acquisition and monitoring system.

A block diagram of the monitoring and analysis system is shown in Figure 43. The entire system, independent of the AN/ARR-52A sonobuoy receiver, was calibrated prior to the flight by inserting selected calibration signals at one third-octave band frequencies between 25 Hz and 2.5 kHz. In addition, a white-noise calibration signal was passed through the system for a complete frequency calibration. The entire calibration procedure was recorded on all data tracks of the monitoring and playback system.

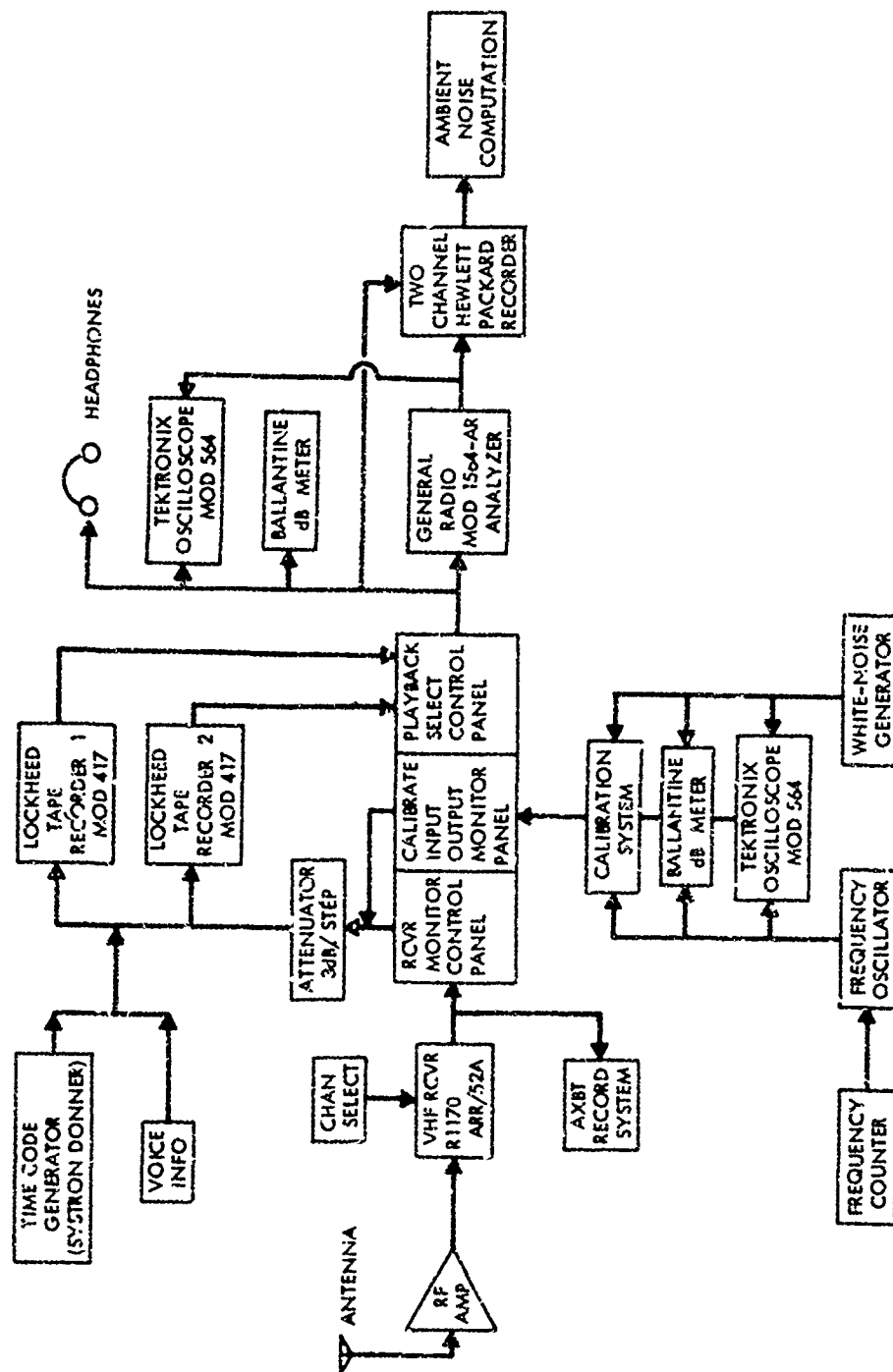
The aircraft AN/ARR-52A sonobuoy receiver system, consisting of eight VHF receivers, was calibrated by NAVOCEANO personnel at the Patuxent River Naval Air Station Avionics Facility. The receiver system was calibrated using AN/ARM-53B and AN/ARM-54A frequency modulated signal generator test sets. These tests enable frequencies at known voltage levels to modulate any sonobuoy receiver VHF channel while monitoring the high and standard audio AN/ARR-52A receiver outputs. For a ± 75 kHz deviation of an rf carrier, the standard audio output is 2 volts and the high audio output is 16 volts over the range of frequencies used in the calibration. The system levels were stepped 20 db to insure system linearity.

The standard, as well as modified, AN/SSQ-57A sonobuoys are air-launched from aircraft at speeds between 150 and 250 knots, and at altitudes between 500 and 10,000 feet. On contact with the water, the sonobuoy deploys an omni-directional hydrophone and preamplifier to a pre-selected depth of either 60 or 300 feet. A shock cord is used to isolate the surface action on the buoy from the hydrophone. In addition, the sonobuoys contain a life-selection switch of 1, 3 or 8 hours, as well as a 20 db attenuation selection switch. The

<u>Tape</u> <u>No</u>	<u>Start of Record</u> <u>Day</u>	<u>Time</u>	<u>Range to</u> <u>PIERCE</u>	<u>SOURCES</u>	<u>ERROR</u>
7-1-1	337	2201	0	NO	
7-1-2	338	0001	0	NO	
7-1-3	338	0201	0	NO	
7-1-4	338	0401	0	NO	
7-1-5	338	0601	0	NO	Recorder A Minor during 15 min. period
7-1-6	338	1001	0	NO	
7-1-7	338	1201	0	NO	
7-1-8	338	1401	0	NO	
7-1-9	338	2201	4.8	HX37	Recorder B Minor during 4 min. period
7-1-10	339	0001	6.0	HX37	
7-1-11	339	0201	7.5	HX37	
7-1-12	339	0401	9.1	HX37	
7-1-13	339	0601	10.5	HX37	
7-1-14	339	0801	12.5	HX37	Large during 15 min. period
7-1-15	339	1001	14.0	HX37	
7-2-1	339	1201	16.1	HX37	Large during 15 min. period
7-2-2	339	1401	18.0	HX37 SUS	Large during 15 min. period
7-2-3	339	1601	19.8	HX37 SUS	Large during last 15 min.
7-2-4	339	1801	21.8	HX37 SUS	Large during last 15 min.
7-2-5	339	2001	23.0	HX37 SUS	Whole record invalid
7-2-6	340	0001	9.0	HX37 SUS	Large during 15 min. period
7-2-7	340	0201	10.9	HX37 SUS	
7-2-8	340	0401	12.6	HX37 SUS	Large during first 15 min.
7-2-9	340	2001	6.2	NO	Large during 30 min. period
7-2-10	340	2201	8.2	NO	
7-2-11	341	0001	9.4	NO	Incorrect record level on Recorder B

VLAM Data Summary

Table V



BLOCK DIAGRAM OF AIRCRAFT MONITORING AND ANALYSIS SYSTEM

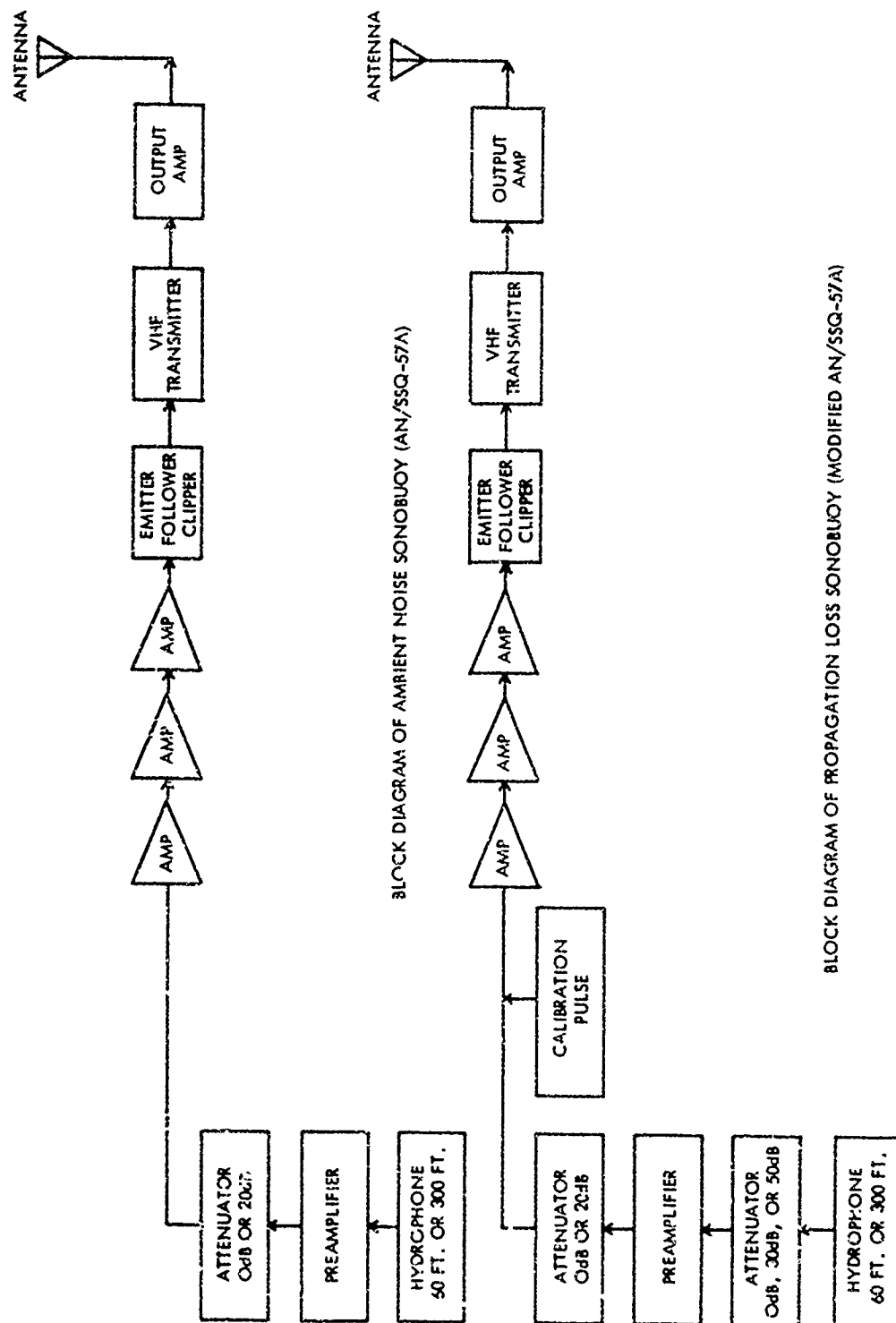
Figure 43

electronics system is capable of transmitting data as soon as a 10 volt sea water battery is activated. These buoys are described in Reference (14).

Block diagrams of both the standard and modified AN/SSQ-57A sonobuoy are shown in figure 44. Each sonobuoy consists basically of a series of attenuator or gain stages followed by a transmitter that telemeters all acoustic information detected by the sonobuoy system to a monitoring aircraft by VHF radio transmission. The sonobuoy FM transmitter operates at carrier frequencies between 162 and 174 megaHertz and consists of a reactance modulator, crystal control oscillator, frequency quadrupler, driver, and final stage RF amplifier. Each sonobuoy has a particular carrier frequency for transmission to a standard AN/ARR-52A VHF receiver onboard an aircraft. The sonobuoy receivers are capable of selecting, receiving and demodulating each RF frequency transmitted, thus enabling them to monitor one or more sonobuoys simultaneously. There are more than 30 VHF carrier frequency assignments for the sonobuoys so several buoys operating at different carrier frequencies can be simultaneously employed without mutual interference. The AN/ARR-52A sonobuoy receiver contains four FM receivers each of which can be automatically tuned to any one of the available channels.

The standard sonobuoys used for ambient noise measurements were calibrated and manufactured for the Navy by Spartan, Inc., of Jackson, Michigan under contract N00019-71-C-0116. Each sonobuoy has an individual calibration curve that is provided to the user by the Naval Air Development Center (NADC) upon request. Usable frequency range at the sonobuoy covers 10 - 3000 Hz; dynamic range is approximately 40 db. The sonobuoy frequency response is between 10 Hz and 20 kHz and is tabulated in db relative to the response of 440 Hz. At 440 Hz an acoustic pressure of +106 db relative to 1 μ Pascal incident on the sonobuoy hydrophone will deviate the sonobuoy carrier \pm 19 kHz.

The modified AN/SSQ-57A sonobuoys used for propagation loss measurements have essentially the same frequency characteristics as the standard ambient noise sonobuoys. However, the modified sonobuoys contain additional attenuator and gain circuitry to prevent overload conditions, as well as a calibration circuit to insure system linearity and assist in data reduction. The attenuator circuit is either 30 db or 50 db, depending upon the sonobuoy selected. The calibration pulse is produced by a multivibrator circuit that gates a phase shift oscillator to produce a two-level (25 db) calibration pulse every 15 seconds at a reference frequency of 2.35 kHz. This calibration circuit is internal to the sonobuoy electronics; the calibration signal produces pulses through the amplifier/transmitter stages and is telemetered to the monitoring aircraft where it is processed and recorded through the data acquisition system.



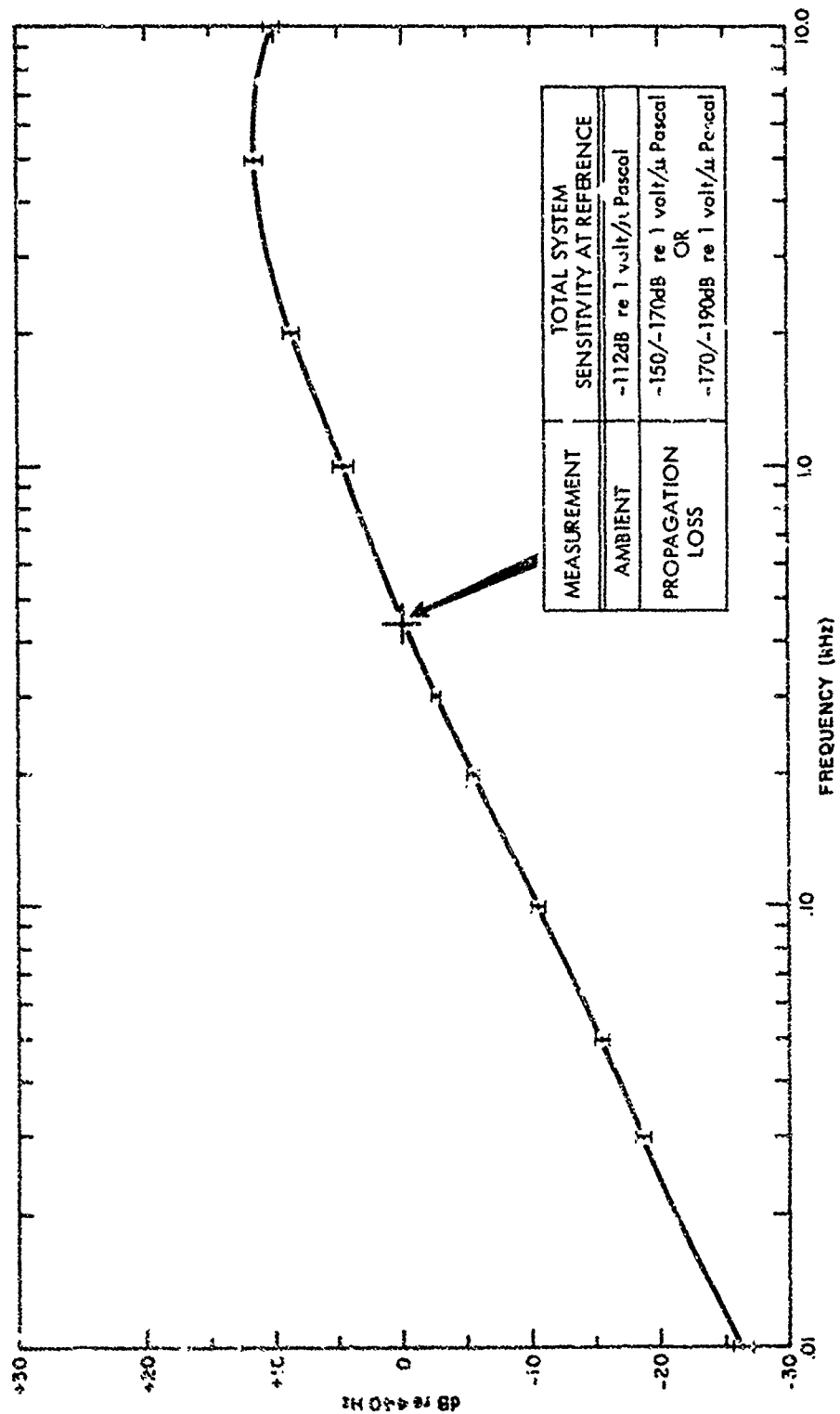
Sonobuoy (AN/SSQ-57A) Block Diagrams

Figure 44

Figure 45 shows the average frequency response and standard deviation of the response, at the calibration frequencies indicated for the modified and unmodified AN/SSQ-57A sonobuoys used in CHURCH GABBRO. Although the response curves for the two types of buoys are the same, the sensitivities are different. The sensitivity for each system at the reference frequency of 440 Hz is noted on the figure. The reference sensitivity is determined from the carrier deviation characteristics of the AN/ARR-52A receiver outputs in conjunction with the acoustic pressure/frequency deviation characteristics of the AN/SSQ-57A sonobuoy. During the present investigation the receiver standard audio outputs were monitored.

Ambient noise and propagation loss data were collected with modified and unmodified AN/SSQ-57A sonobuoys with hydrophone depths of 60 and 300 feet. As many as eight sonobuoys were monitored simultaneously for ambient noise and explosive sound source arrivals. All data were recorded broadband on magnetic tape and a preliminary examination of the monitored data was made using a General Radio model 1564-AR one-third octave/one-tenth octave analyzer, and associated analog display. No major problems were encountered with the data acquisition system.

AN/SSQ-57A sonobuoys were also deployed from SANDS during the aircraft SUS run. The sonobuoy data acquisition system aboard SANDS is similar to that for TABS and consists of AN/SSQ-57A sonobuoys, an AN/ARR-52 sonobuoy receiver, Ithaco amplifier, a CF-100 magnetic tape recorder and two Bruel and Kjaer 1/3 octave band pass filter sets; see Figure 46. Receiving and recording system calibrations were accomplished separately. The receiver was calibrated using a Boonton 202H FM generator and a frequency counter with a high frequency converter. A center frequency corresponding to a particular sonobuoy channel was selected and modulated at 1 kHz by the Boonton FM generator. This test signal was inserted into the sonobuoy receiver. Each receiver channel to be used was calibrated while monitoring the High Audio Output. The High Audio Output has a low frequency cut off of 10 Hz. The deviation of the center frequency was set at ± 75 kHz and a check was made to insure the proper amplitude of 16 volts was measured at the receiver output. The deviation was then varied from ± 75 kHz down to ± 20 kHz. This was done to check the receivers' linearity and, by graphic methods, to obtain an output level for a deviation of ± 19 kHz. Because the receiving response is flat over the audio frequencies of interest, one can utilize the output level obtained for a ± 19 kHz deviation and the factory supplied sonobuoy calibration data to obtain a graph of terminal sensitivity (db re v/uPa) vs. frequency. The High Audio Output of the receiver was used because of the increased frequency response it provided, however, this did require attenuation of the input to the tape recorder data channels of 25 db. The recorder was calibrated by sequentially inserting, at a known level, all 1/3 octave band center



AN/SSQ - 57A SONOBUOY FREQUENCY RESPONSE CURVE IN dB re 440 Hz

Figure 45

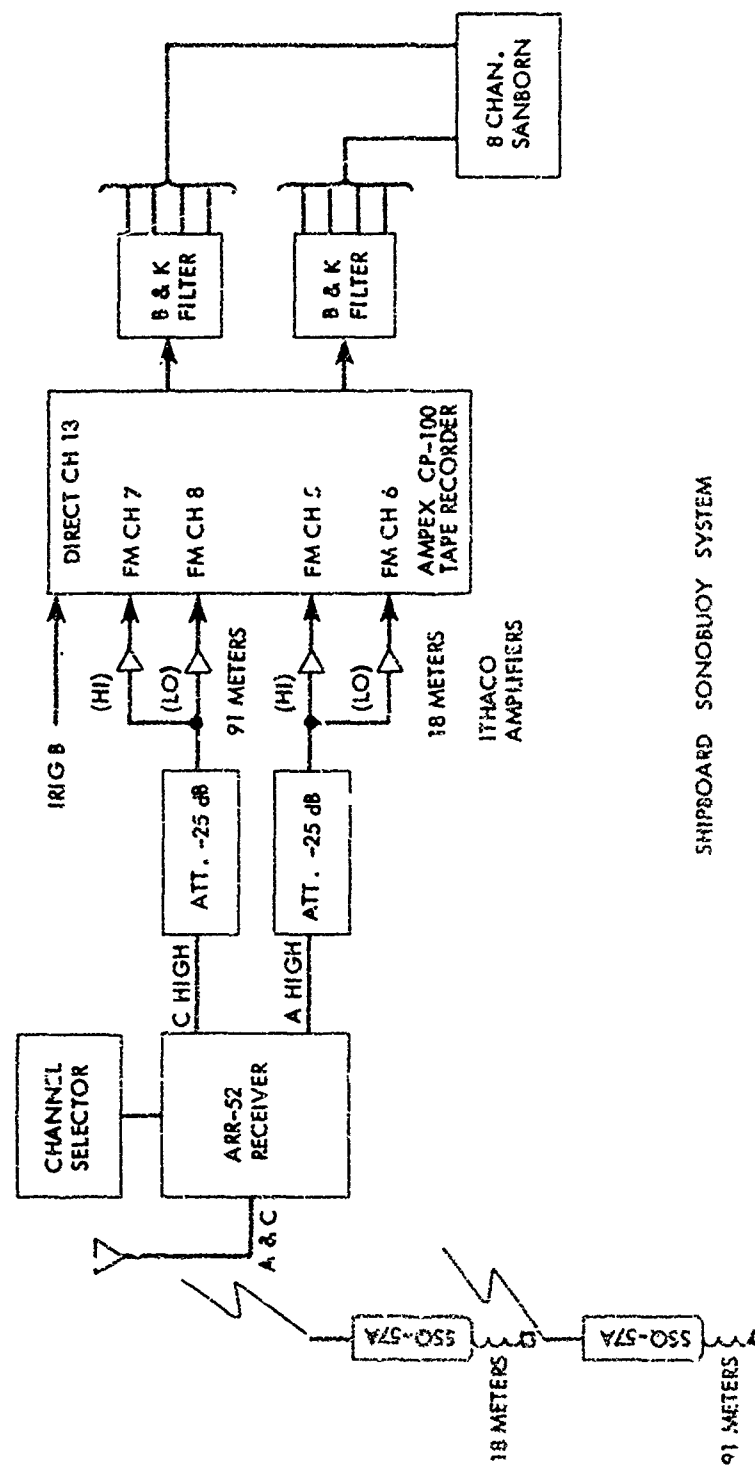


Figure 46

frequencies, from 10 Hz to 2000 Hz, at the input of the 25 db attenuators and recording the levels on the data channels.

Both 60 and 300 foot depth sonobuoys were deployed from SANDS during the aircraft SUS run of 7 December. Both units employed the eight hour life option and the additional 20 db of attenuation. Signals were generally successfully recorded on magnetic tape. A problem with the shipboard antenna connector occurred during the run; however, very little data appear to have been lost.

2.2 Acoustic Sources

2.2.1 SUS Charges, Mk 61 - Mod 0, and Mk 82 - Mod 0

On 7 December, the VXN-8 aircraft dropped 478 Mk 61 and Mk 82 SUS for propagation loss measurements. In addition, NORTH SEAL dropped an additional 1104 Mk 82 charges on 4 and 5 December. A description of these charges and launching procedures can be obtained from References (3), (15), and (17).

2.2.2. Piezoelectric, HX 231-F

A Honeywell HX 231-F dual frequency sinusoidal source was towed by SANDS during the exercise. The HX 231-F consists of four sections with each section being a lead zirconate titanate ceramic bender bar transducer driven by a step-up auto-transformer having a turns ratio of 1:8. The physical dimensions of the HX 231-F are 32 inches in diameter, 80 inches high, with an air weight of 3,700 lbs. The maximum operating depth is 675 feet with non-operating depth to 1000 feet. Approximately 130 gallons of GE-10C transformer oil is used to fill the transducer and transformer compartment. At resonance the transducer is stress limited and the maximum voltage allowed the ceramic is 2320 V RMS; off resonance, the maximum voltage drive is 3,000 V RMS. Each element was checked at Honeywell at 4,000 V RMS. Table VI summarizes its characteristics. Figure 47 plots frequency response; HX 231-D is equivalent to HX 231-F.

The HX 231-F transducer was manufactured by Honeywell, Seattle, Washington, and delivered to the Lake Pend Oreille Test Facility in May 1972; see Reference (18). There the projector was extensively tested. The transducer was then shipped to NUSC's Lake Seneca Test Facility in New York for further calibration and testing. These tests included beam patterns at various frequencies, current and voltage transmitting responses, phase and impedance measurements, and linearity tests.

A two frequency (85.470 Hz and 128.205 Hz) harmonic sine wave generator was designed and built and used as input to drive mixed frequency. This particular HX 231-F was dockside tested in July 1972 and was again tested in shallow and deep water in the North Atlantic to confirm source level measurements using a monitor hydrophone. Also during the NORLANT Operation the source operated satisfactorily for two 12-hour periods while being "dipped". Subsequently, during that operation the source had an arc-over on one of the elements. This

PHYSICAL SPECIFICATIONS

HX-231-F

° Number of modules	2
° Number of bars	28
° Weight in air	3700 pounds
° Exterior envelope	
Length	80 inches
Diameter to contain unit	32 inches

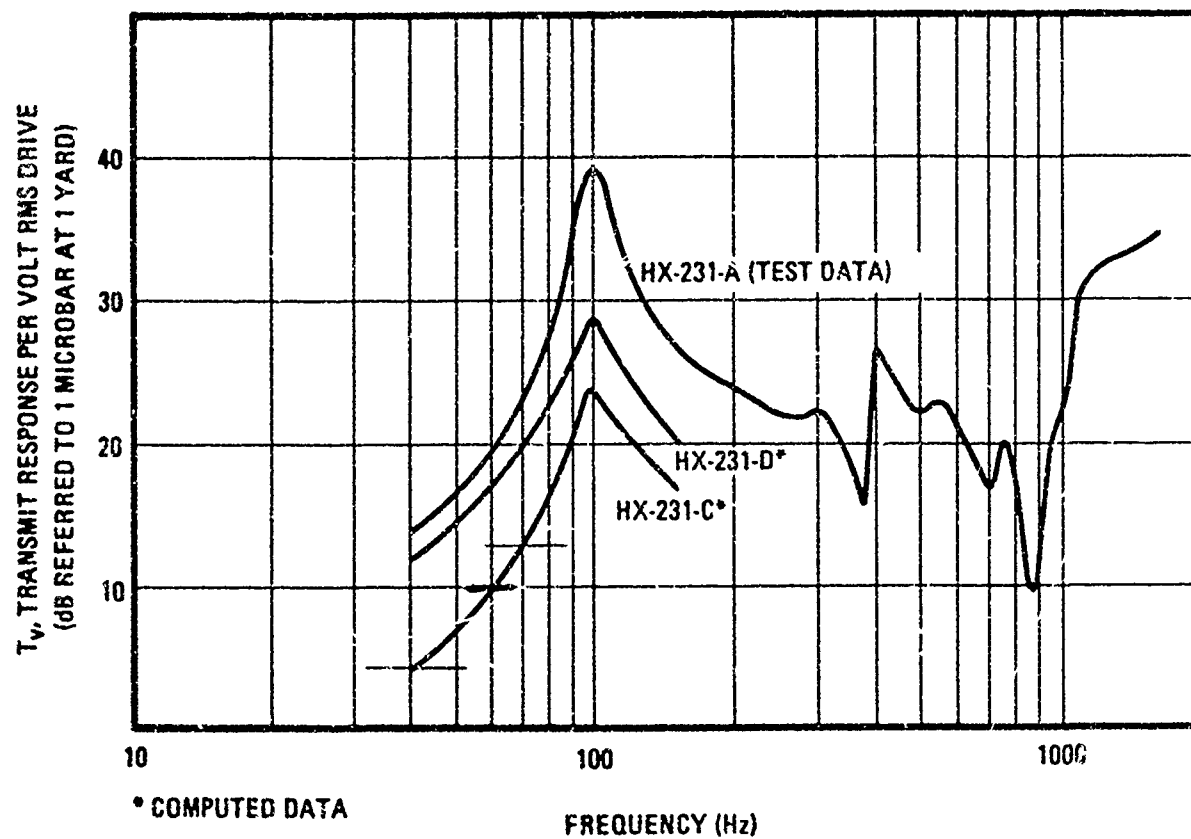
PERFORMANCE CHARACTERISTICS

HX-231-F

° Resonant frequency	100 Hz
° Maximum measured output power at f_r	—
° Maximum measured source level at f_r (re 1 microbar at 1 yard) r	92
° Drive at maximum measured source level at f_r	—
° Calculated maximum source level possible at f_r	102 dB
° Directivity at f_r	Omni
° Transmitting efficiency at f_r	20 percent
° Measured Q_m	—
° Maximum operating depth	675 feet
° Input impedance at f_r	—

HX-231-F Data

Table VI



TRANSMITTING RESPONSE, HX-231 SERIES

Figure 47

breakdown was repaired before the subject exercise by replacing the faulty element.

Prior to CHURCH GABBRO the source was life tested at NUSC's Dodge Pond Facility. This test consisted of driving the source using the mixed frequency generator and a CML power amplifier for a period of 72 hours. The source was at 25 feet and operated quite well during the test. The maximum ceramic voltage was lowered to 2000 V RMS off resonance as recommended by Mr. J. White of NUSC (Code TD12).

Before the CHURCH GABBRO exercise the source was outfitted with a tow body and towing tests were planned during a shake-down cruise. However, severe weather prevented these tests at that time. Towing tests were conducted on 29 November in the Caribbean at 300 ft. depth and the source failed after about two hours. Again the problem was caused by an element arcing and shorting. This was repaired while SANDS was in port for the pre-sail conference. On 3 December at the start of the tow exercise the source had another element failure. Again this was repaired at sea. On 5 December the source was towed again and again failed. This was caused by arc-over on the terminal board (some oil may have been lost during previous repairs). The terminal board was then relocated so as to totally immerse the board in oil. In the meantime a problem had developed in the lead-in cable between the transducer and the tow cable (~660" faired cable). The cable eventually flooded and destroyed the connector to the transducer. This effectively terminated the use of the source during the exercise.

The source was powered for periods totaling 19 hours and over 155 nautical miles. This was accomplished at reduced source level (~83 db) with most of the area between Positions B and C.

The problem with the elements of the transducer appears to be a manufacturer's design deficiency. The design of the unit should be critically reviewed and a series of tests at pressure and temperature should be conducted before further usage. While towing the unit at 91 meters, SANDS was not able to make her appointed SOA of 10 knots. The SOA was actually in the order of 8 - 9 knots.

2.2.3 Hydroacoustic (VIBROSEIS)

A. Responsibilities

The DELTA Exploration Company, Inc. of Houston, Texas furnished the M/V DEARBORN outfitted with a vibrator system, operational personnel and necessary auxiliary systems such as navigation. The DEARBORN task was to tow CW sound sources at 18 m and 92 m depth simultaneously from the Yucatan Channel across the Yucatan Basin and up the Cayman Trough to the Windward Passage from 1100Z 29 November to

0300Z 13 December. Environmental measurements including XBTs were to be taken enroute.

B. DELTA's Marine Acoustic Energy Source

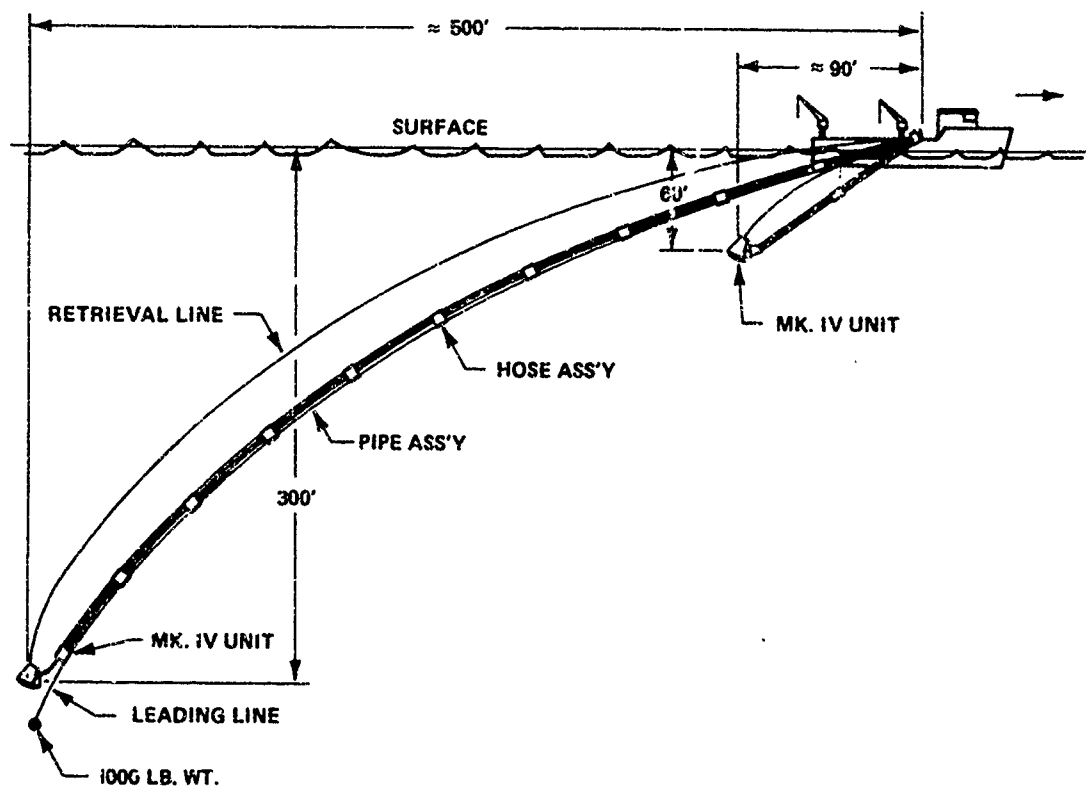
The vibrator system, known as the MK IV vibrator system has been used by Delta Exploration Company for furnishing commercial exploration services for petroleum. Techniques in operating this equipment and the equipment employed are nearly identical to standard operating practice in the off-shore seismic survey work. The portion of the system which had not been actually utilized before, was the loading apparatus required for the deep towing of the vibrator. The operation of the vibrator in depths up to 92 m was not considered to be a major technical problem since, in all cases, the average pressure in the vibrator was carefully regulated to be equivalent to the hydrostatic pressure of the vibrator. The air system also provided an accurate measure of the pressure-depth of the transducer at all times.

Figure 48 is a concept sketch showing the towing arrangement. The towing mechanism consists of the leading line, the pipe and hose assembly and the retrieval line. The required hydraulic, electrical and air circuits are routed through the pipe and hose assembly which in turn is connected to the leading line in such a manner that the whole assembly represents a faired surface. The towing forces for the transducer are taken by a wire rope assembly and the retrieving line is used to raise and lower the whole assembly.

The deck handling procedure consists of folding the pipe and hose assembly into specially prepared racks on the deck of the boat. There are special handling devices to facilitate the loading and unloading of the transducer. A complete loading or unloading operation can be completed in about two hours. Figure 49 shows deck handling devices on DEARBORN.

Technical literature pertaining to VIBROSEIS system is included in references (4), (5), (8), (9), (11), and (12).

Except for the mechanical handling problems, no special difficulty was expected in operating the vibrators in the hove-to condition. Because of the unpredictable hydrodynamic characteristics of the towing assembly and transducer, the maximum towing speed of the assembly was not known. The vibrator system itself consists of the transducer, the hydraulic power supply, the servo electronic system and the air control system. The hydraulic supply consists of self-contained diesel engines driving variable displacement pumps capable of maintaining constant pressures with variable flows. The transducer, the Mark IV vibrator, consists of two 48 inch diameter hemispheres connected by a hydraulic ram capable of mechanical expansion and contraction of the surfaces relative to each other to produce the acoustic pressure wave which is desired. The transducer is controlled by a



VIBROSEIS SOUND SOURCE SYSTEM, ILLUSTRATING
TOWING ARRANGEMENT

Figure 48



DEPARTMENT OF THE NAVY

OFFICE OF NAVAL RESEARCH
875 NORTH RANDOLPH STREET
SUITE 1425
ARLINGTON VA 22203-1995

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Declassified LRAPP Documents

Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
Unavailable	Brancart, C. P.	TRANSMISSION REPORT, VIBROSEIS CW ACOUSTIC SOURCE, CHURCH ANCHOR EXERCISE, AUGUST AND SEPTEMBER 1973	B-K Dynamics, Inc.	730101	AD0528904	U
Unavailable	Daubin, S. C., et al.	LONG RANGE ACOUSTIC PROPAGATION PROJECT. BLAKE TEST SYNOPSIS REPORT	University of Miami, Rosenstiel School of Marine and Atmospheric Science	730101	AD0768995	U
NUSC TR NO. 4457	King, P. C., et al.	MOORED ACOUSTIC BUOY SYSTEM (MABS): SPECIFICATIONS AND DEPLOYMENTS	Naval Underwater Systems Center	730105	AD0756181; ND	U
MC-012	Unavailable	CHURCH GABBRO SYNOPSIS REPORT (U)	Maury Center for Ocean Science	730210	ND	U
Unavailable	Hecht, R. J., et al.	STATISTICAL ANALYSIS OF OCEAN NOISE	Underwater Systems, Inc.	730220	AD0526024	U
Raff rept 73-2	Bowen, J. I., et al.	EASTLANT SHIPPING DENSITIES	Raff Associates, Inc.	730227	ND	U
Unavailable	Sander, E. L.	SHIPPING SURVEILLANCE DATA FOR CHURCH GABBRO	Raff Associates, Inc.	730315	AD0765360	U
Unavailable	Wagstaff, R. A.	RANDI: RESEARCH AMBIENT NOISE DIRECTIONALITY MODEL	Naval Undersea Center	730401	AD0760692	U
Unavailable	Van Wyckhouse, R. J.	SYNTHETIC BATHYMETRIC PROFILING SYSTEM (SYNBAPS)	Naval Oceanographic Office	730501	AD0762070	U
MCPLAN012	Unavailable	SQUARE DEAL EXERCISE PLAN (U)	Maury Center for Ocean Science	730501	NS; ND	U
Unavailable	Marshall, S. W.	AMBIENT NOISE AND SIGNAL-TO-NOISE PROFILES IN IOMEDEX	Naval Research Laboratory	730601	AD0527037	U
Unavailable	Daubin, S. C.	CHURCH GABBRO TECHNICAL NOTE: SYSTEMS DESCRIPTION AND PERFORMANCE	University of Miami, Rosenstiel School of Marine and Atmospheric Science	730601	AD0763460	U
MC-011	Unavailable	CHURCH ANCHOR EXERCISE PLAN (U)	Maury Center for Ocean Science	730601	ND	U
Unavailable	Solosko, R. B.	SEMI-AUTOMATIC SYSTEM FOR DIGITIZING BATHYMETRY CHARTS	Calspan Corp.	730613	AD0761647	U
64	Jones, C. H.	LRAPP VERTICAL ARRAY- PHASE II	Westinghouse Research Laboratories	730613	AD0786239; ND	U
Unavailable	Koenigs, P. D., et al.	ANALYSIS OF PROPAGATION LOSS AND SIGNAL-TO-NOISE RATIOS FROM IOMEDEX	Naval Underwater Systems Center	730615	AD0526552	U
NUSC TR 4417	Perrone, A. J.	INFRASONIC AND LOW-FREQUENCY AMBIENT-NOISE MEASUREMENTS OFF NEWFOUNDLAND	Naval Underwater Systems Center	730619	AD 913668	U
USRD Cal. Report No. 3576	Unavailable	CALIBRATION OF FLIP-CHURCH ANCHOR TRANSDUCERS SERIALS 15 AND 19	Naval Research Laboratory	730716	ND	U